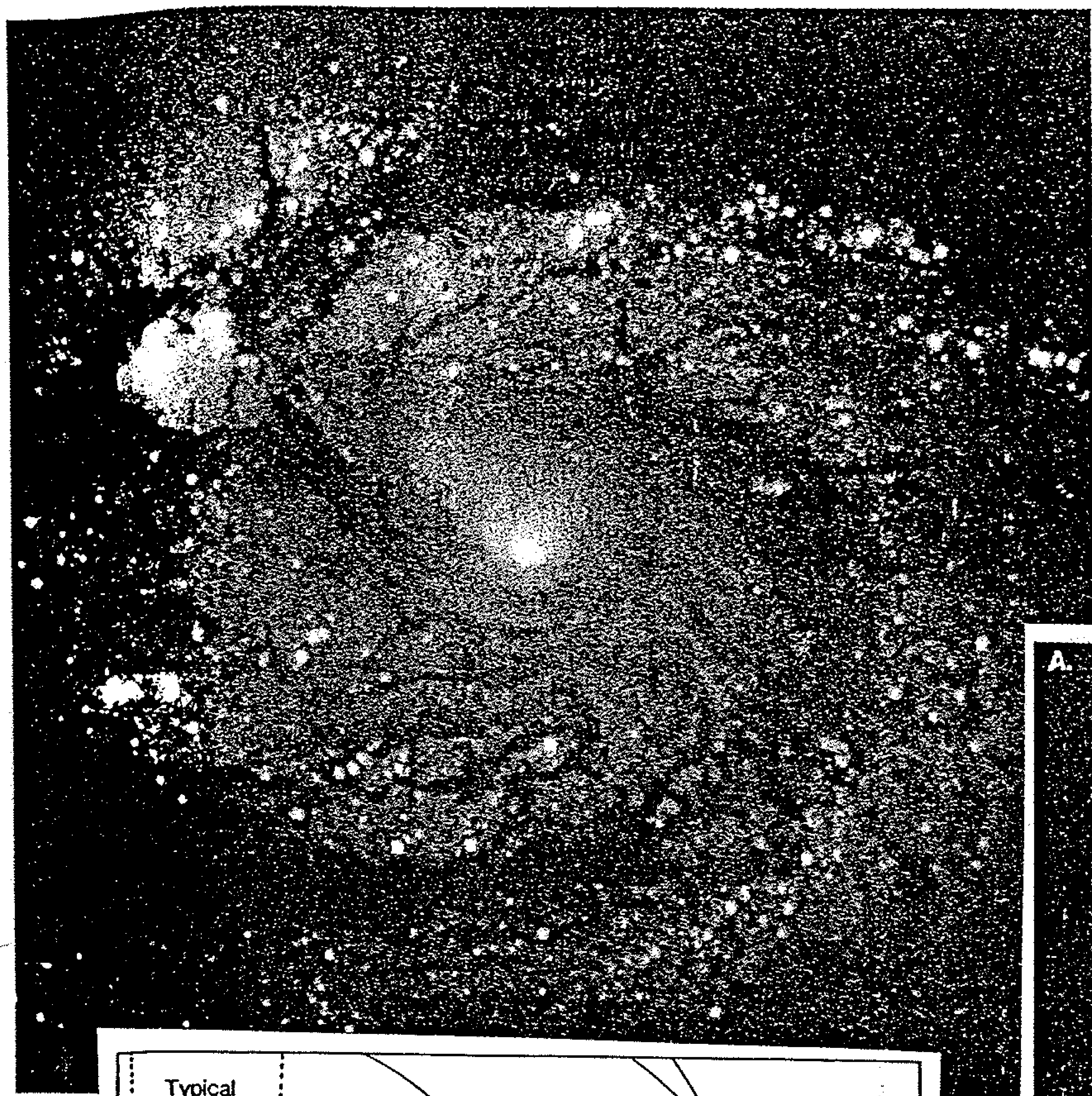


Figure 4.1. Hubble Space Telescope image of the core of galaxy M100, one of the more prominent members of the Virgo Cluster of galaxies. M100 is very similar to our own galaxy (the Milky Way) in its overall spiral arrangement of luminous matter (stars). See color plate section for color version of this figure. (*Source:* Courtesy of NASA, 1995.)

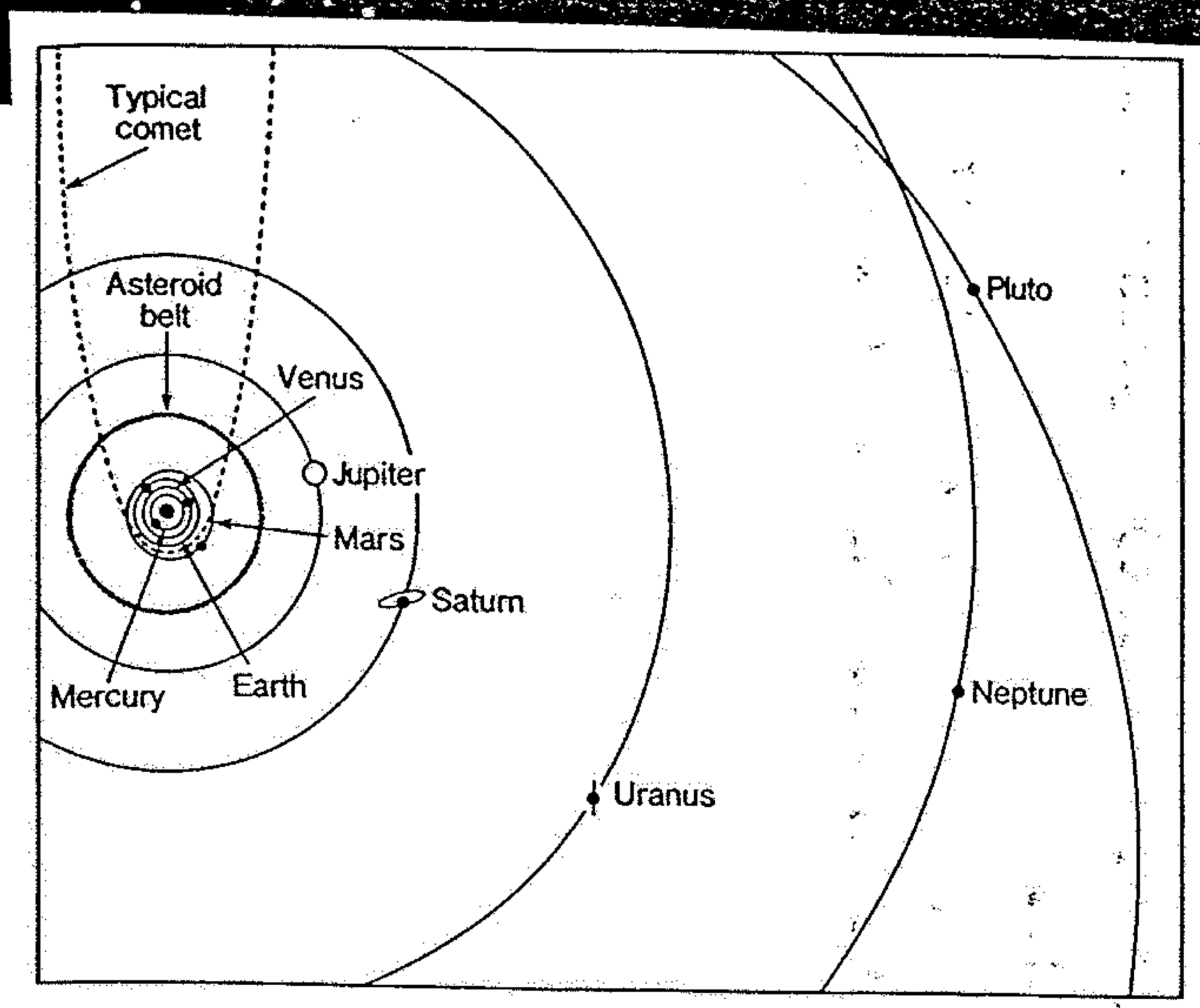


Figure 4.4. Orbits of the nine planets in the solar system, a typical comet in Sun-approaching orbit, and the asteroid belt, with radii properly scaled. Sizes of the planets and the Sun are illustrated diagrammatically. The ring systems of Saturn and Uranus are indicated schematically. (*Source:* W. K. Hartmann, *Moon and planets*, Wadsworth Publishing, 1983.)

TABLE 4.1. DISTANCES FROM THE SUN, DIAMETERS, AND TYPES OF PLANETS IN THE SOLAR SYSTEM

	Distance from Sun (in AU[a])	Diameter of Planet (in km)	Planetary Type
Mercury	0.4	4,878	Iron/stony
Venus	0.7	12,104	Stony
Earth	1.0	12,756	Stony
Moon	1.0	3,476	Stony
Mars	1.5	6,796	Stony
Asteroids	~2.8	small	Stony
Jupiter	5.2	142,796	Gassy
Saturn	9.5	120,660	Gassy
Uranus	19.2	50,800	Gassy/icy
Neptune	30.0	48,600	Icy
Pluto	39.4	2,400–3,800	Icy
(Oort cloud)	100–50,000	small	Icy

[a] One astronomical unit (AU) is the distance between the Earth and Sun, approximately 149,600,000 kilometers.

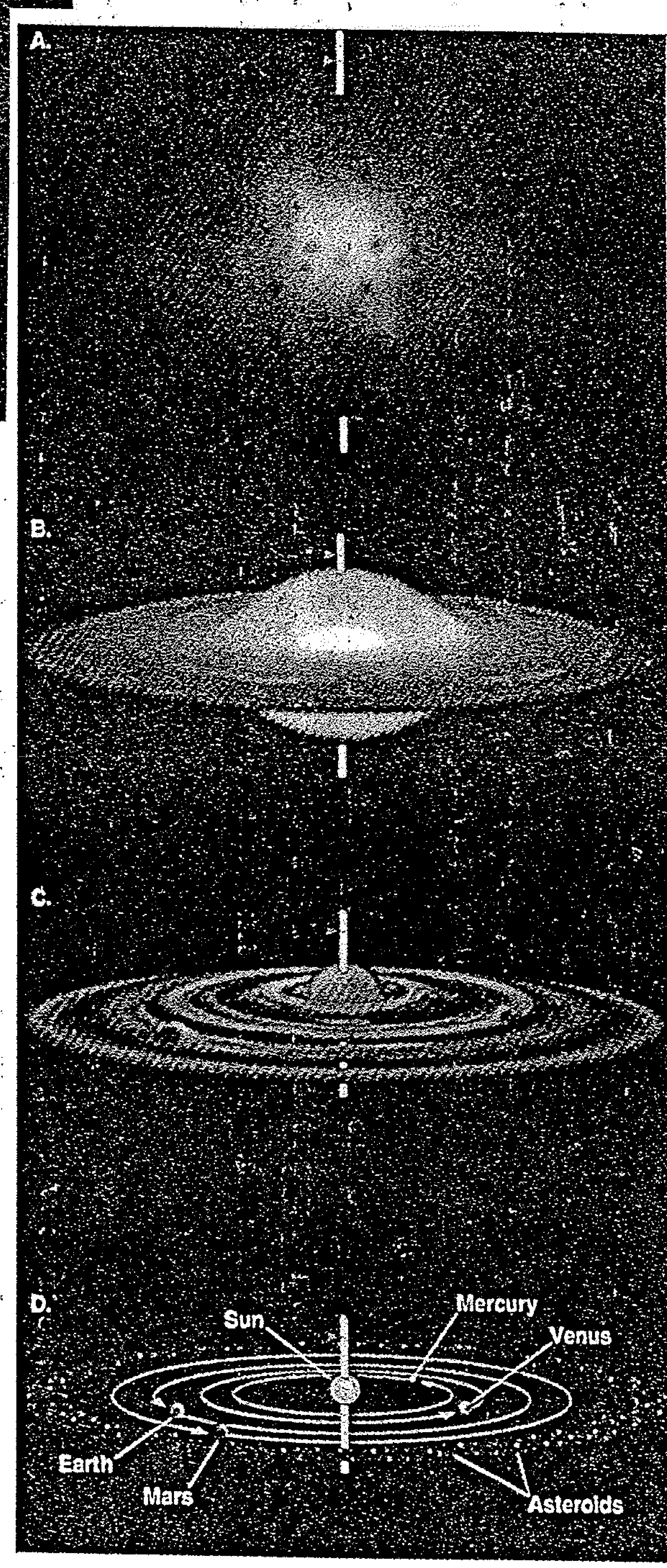
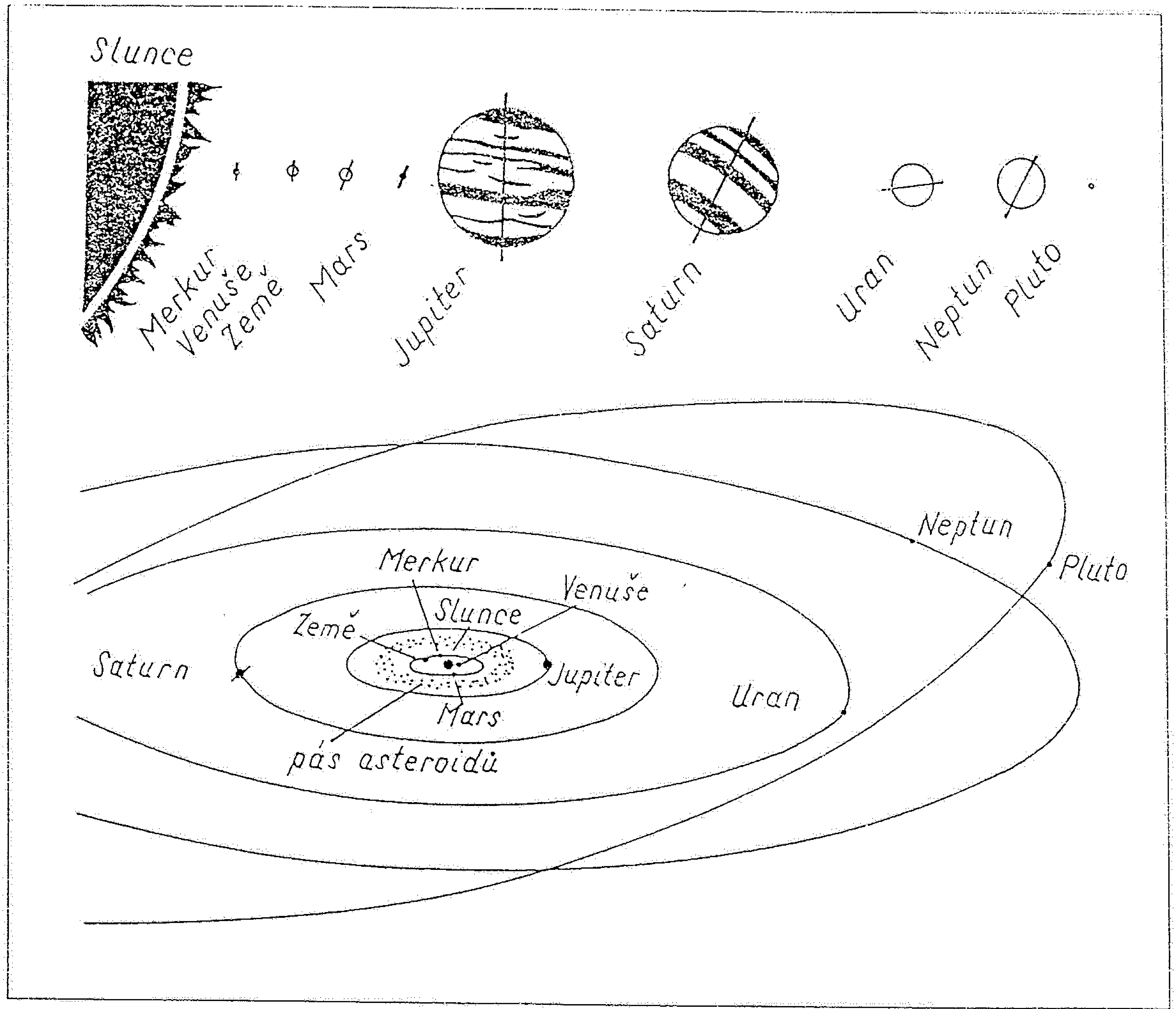
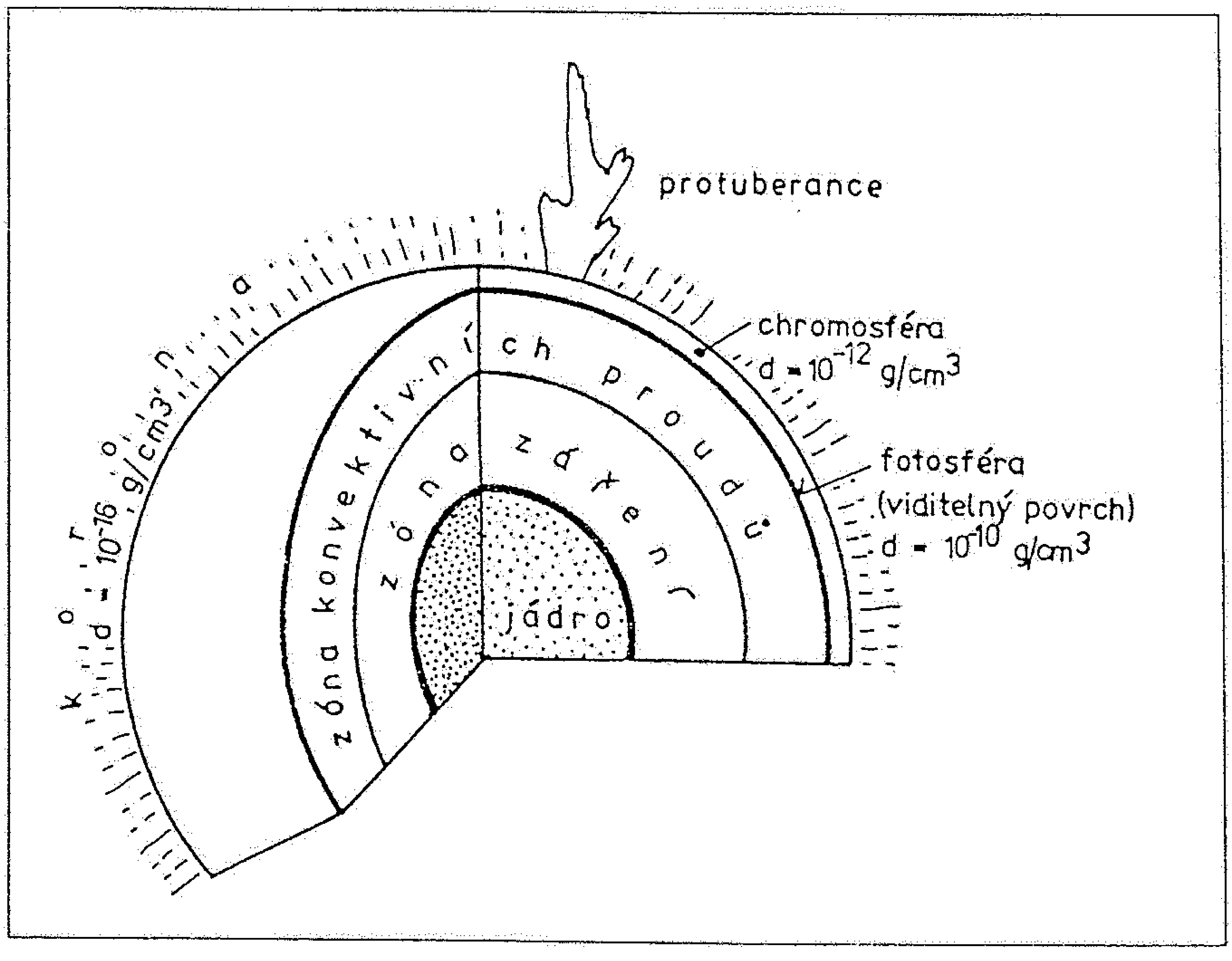


Figure 4.2. Inferred stages in the collapse of the solar nebula to form the Sun and planetesimal debris in the plane of the ecliptic (based on an illustration from Skinner and Porter, 1987). As the slowly rotating nebula shown in (A) began to condense, it spun up condensed matter in the zodiacal disk, as illustrated in (B) with progressively more evolved states shown in (C) and (D). (*Source:* B. J. Skinner and S. C. Porter, The dynamic Earth, John Wiley & Sons, © 1987.)

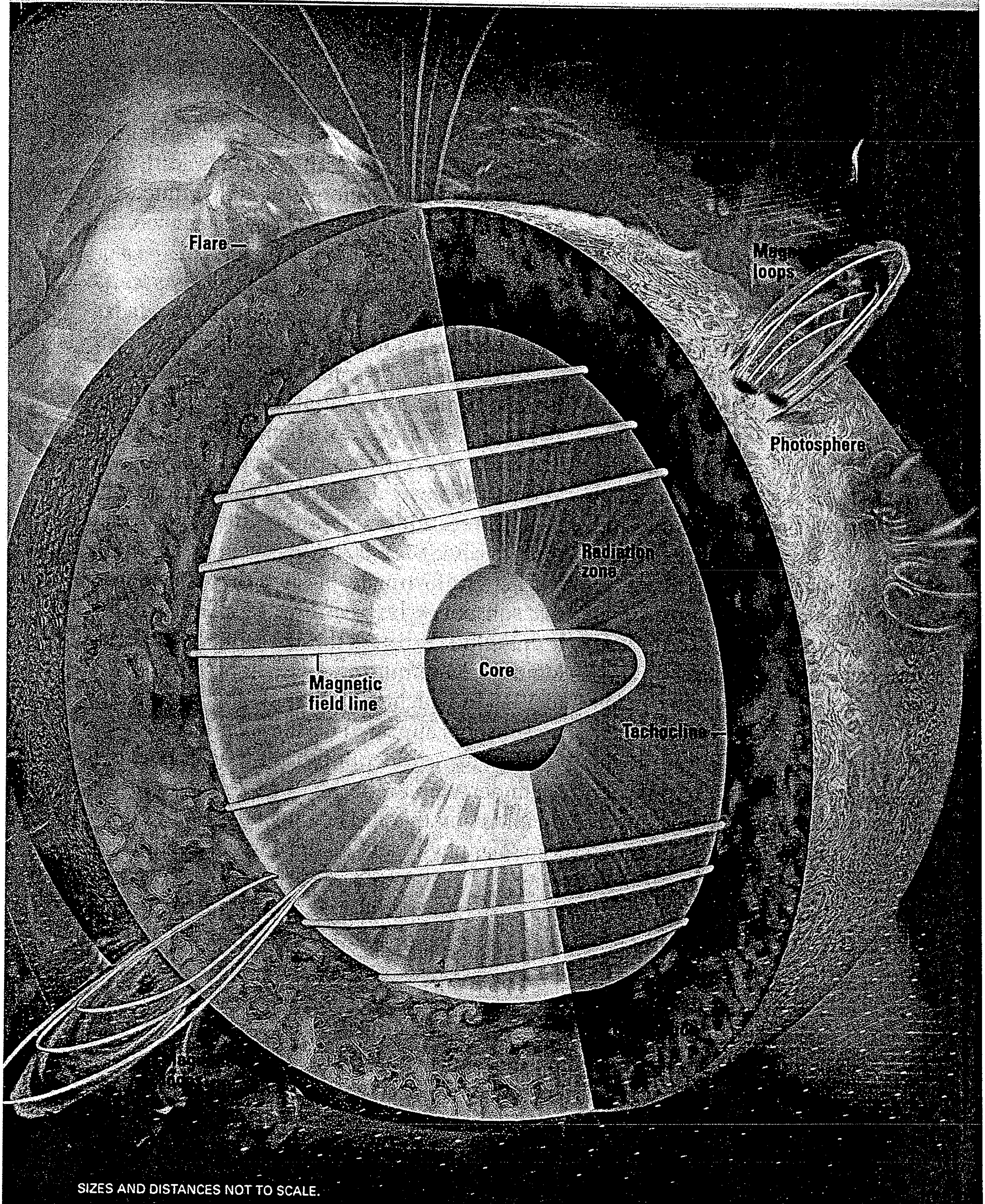


Obr. 4: Znázornění relativní velikosti Slunce a planet, jejich oběžných drah a náklonu osy rotace v případech, že je znám (upraveno a doplněno podle Press, Siever 1975 in Tonika 1983)

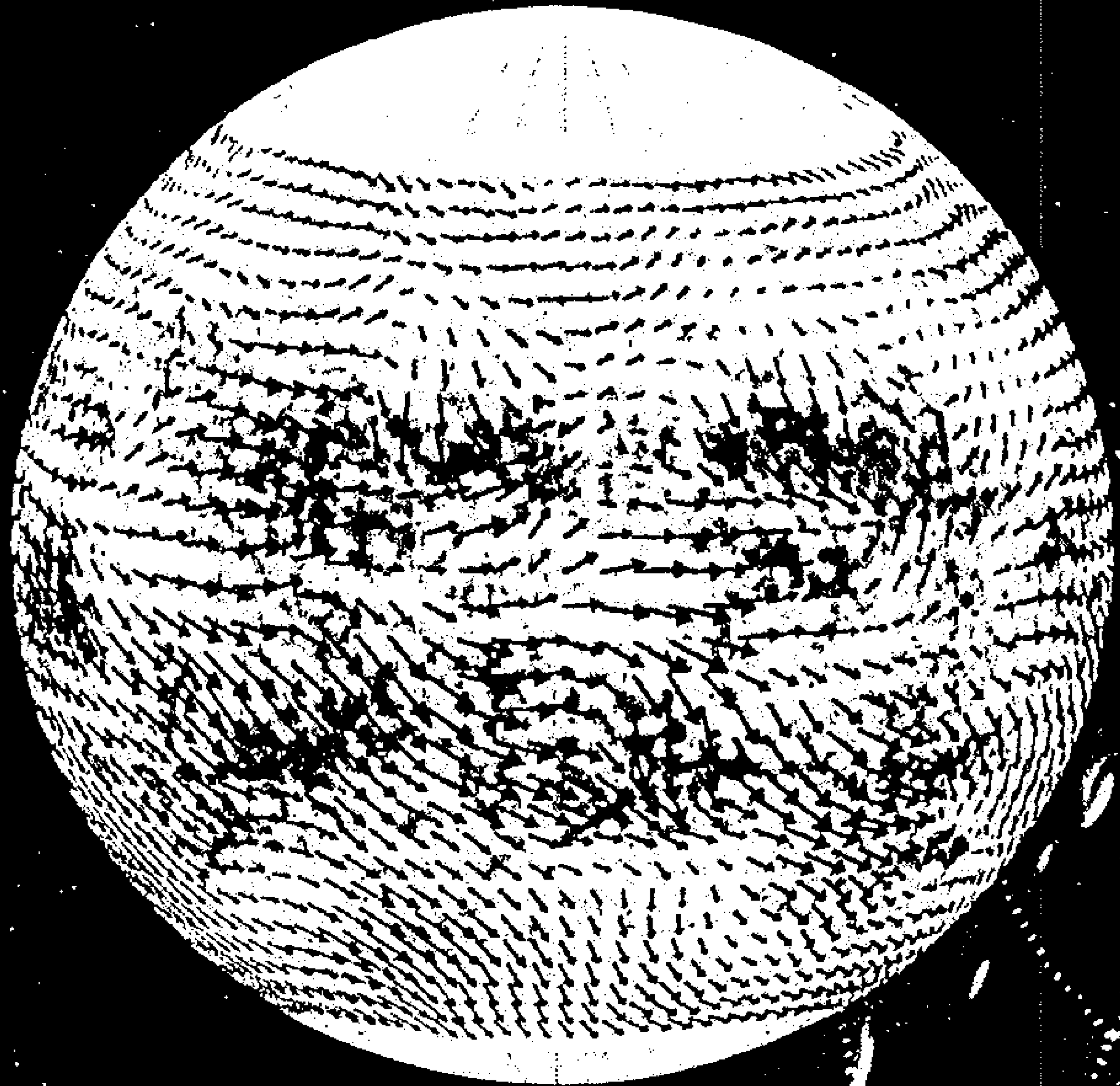


Obr. 3: Vnitřní stavba Slunce (převzato z Bouška et. al., eds. 1980)

3. Skládá se z jádra o teplotě až 10 000° K, radiativní zóny (zóna záření), konvektivní zóny, chromosféry a korony.



SIZES AND DISTANCES NOT TO SCALE.



thousands of miles deep in the convection zone reveal shifting "jet streams" of plasma (above). Computer modeling (right) maps this internal weather—big fronts at the equator, small cyclonic storms at high latitudes.

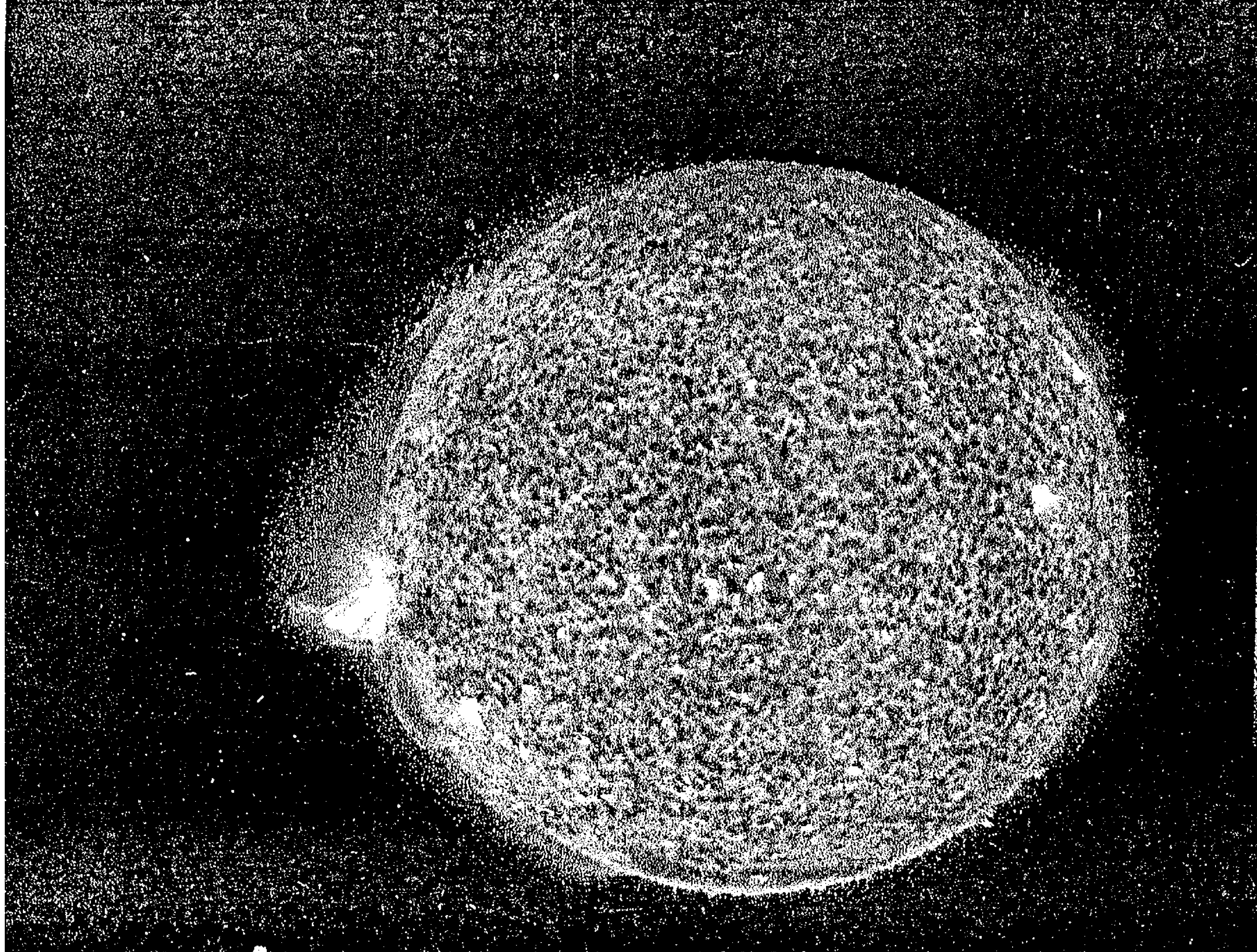
CLOCKWISE FROM BOTTOM LEFT: A. G. KOSOVICHEV, T. L. DUVALL, JR., P. H. SCHERRER, STANFORD UNIVERSITY, SOHO/MICHELSON DOPPLER IMAGER, ESA AND NASA. ART BY KENNETH EWARD. DEBORAH HABER, BRADLEY HINDMAN, AND JURI TOOMRE, JILA/UNIVERSITY OF COLORADO. ALLAN BRUN, CEA, JURI TOOMRE, AND MARK MIESCH, HIGH ALTITUDE OBSERVATORY/NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (HAO/NCAR)

▶ View movie at nationalgeographic.com/magazine/0407

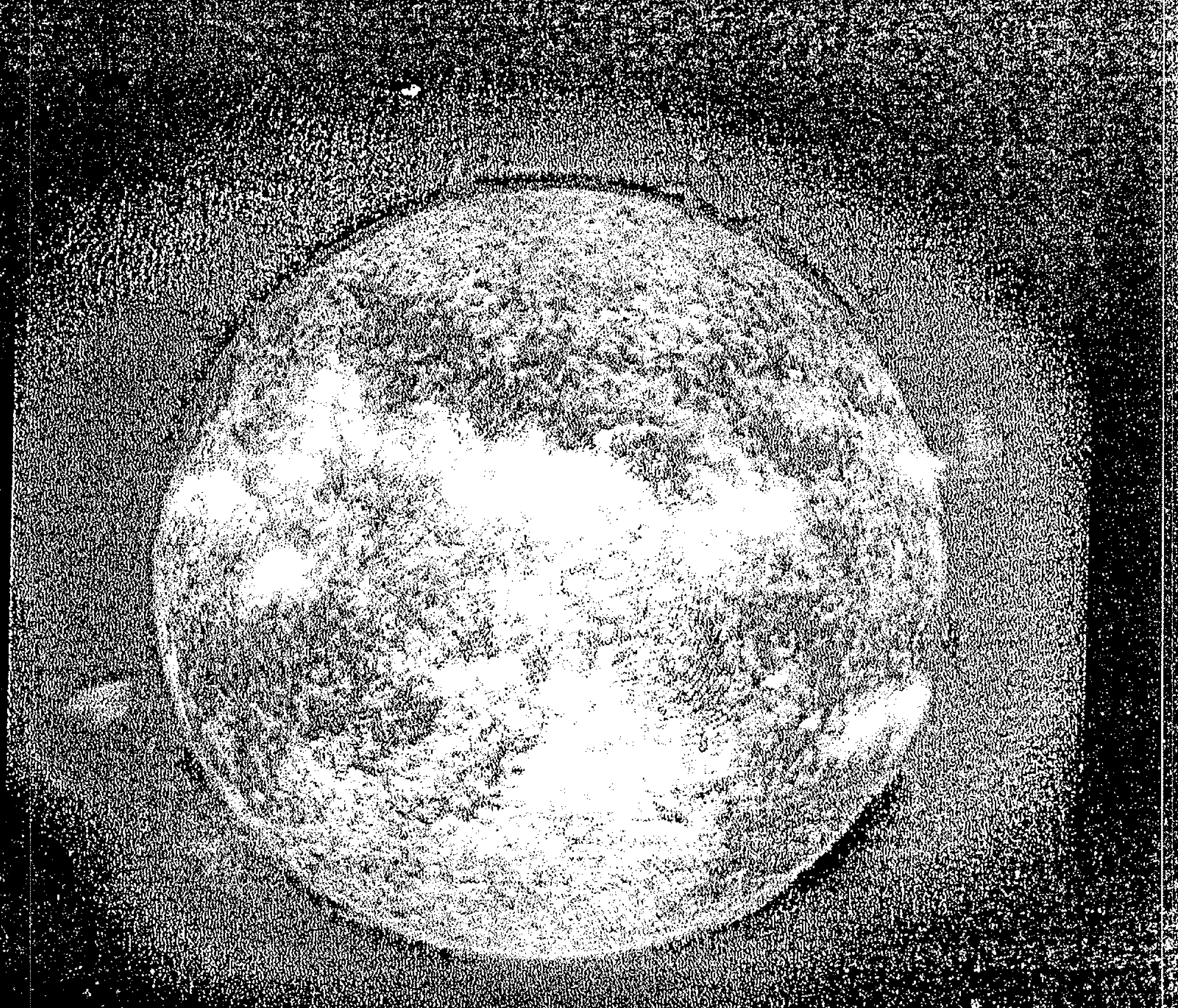
THE HOLY GRAIL for solar scientists is to understand the sunspot cycle. Sunspot activity goes from minimum to maximum and back over a period of 11 years on average, though it ranges from 8 to 15 years. During this time, the sun's main magnetic field is reversing itself. The north pole becomes the south pole, then flips back during the next cycle. Sunspots form when monstrous bundles of magnetic field lines break the sun's surface and mark where the magnetic field is strongest. Computer models of the field's reversal (right, bottom) help researchers as they ponder: Why does the timing of the reversal vary? And why do some cycles produce many sunspots and others very few (graph)?

SOHO/EIT, ESA AND NASA (BELOW); GRAPH DATA FROM NASA; MAGNETIC FIELD MODEL BY MAUSUMI DIKPATI, HAO/NCAR

▶ View movie at nationalgeographic.com/magazine/0407

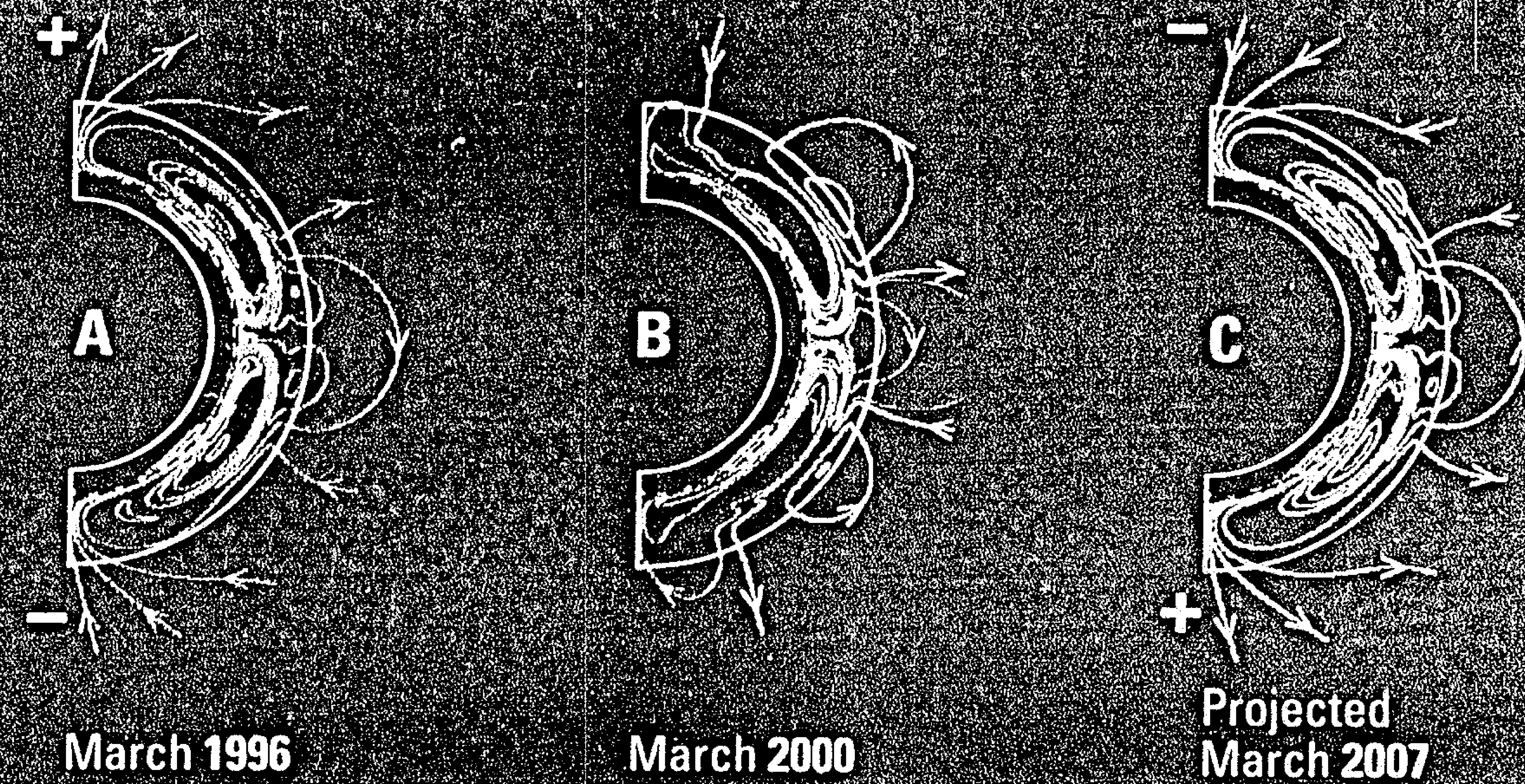


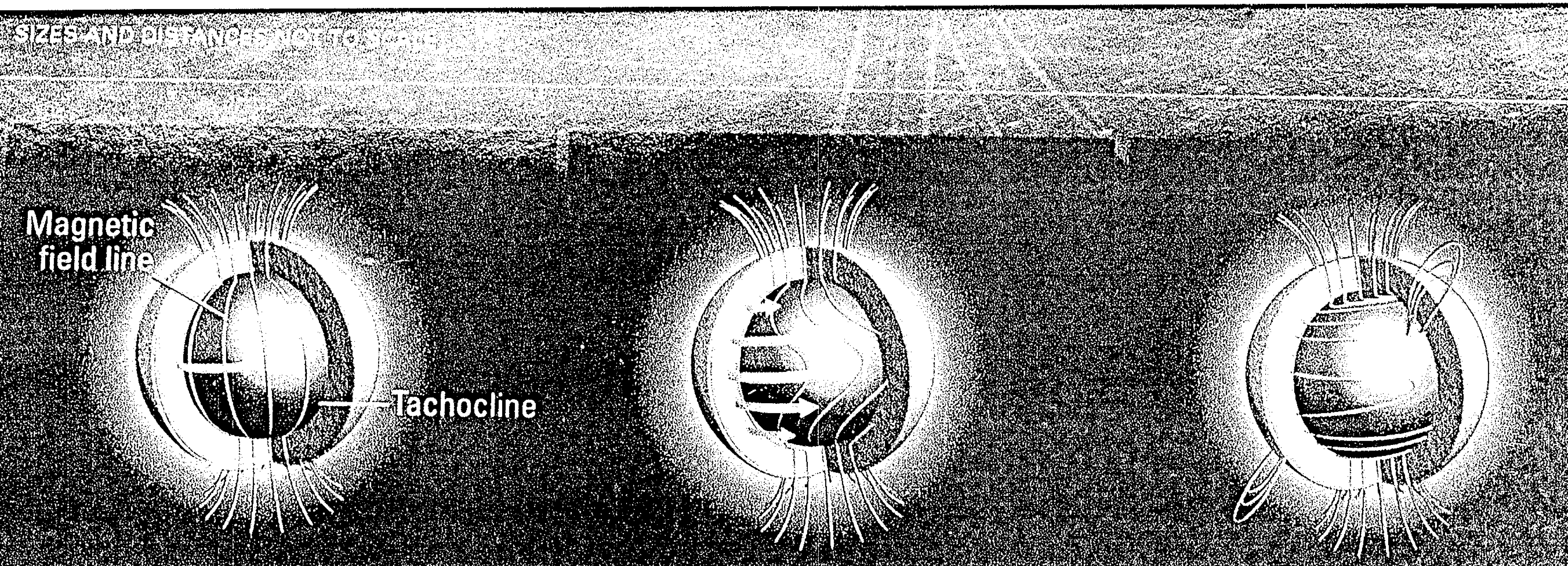
A Solar minimum March 1996



B Solar maximum March 2000

At solar minimum the magnetic field is strongest near the poles (A, red). Solar max (B) occurs as field strength concentrates near the equator, creating storms that can affect Earth. By the next minimum (C), a new polarity (blue) has been carried by plasma through the convection zone.





The Sun Revs Up

The cycle begins with magnetic field lines running from pole to pole—the field generated in the tachocline, where the radiation and convection zones slide past each other. Since the sun's upper layers rotate faster near the equator (about 26 days) than near the poles (about 36 days), the lines begin to stretch. As plasma churns and flows, it further drags and distorts the lines, which energizes them. When field lines become twisted they gain buoyancy and rise, then break through the surface in a variety of breathtaking forms.

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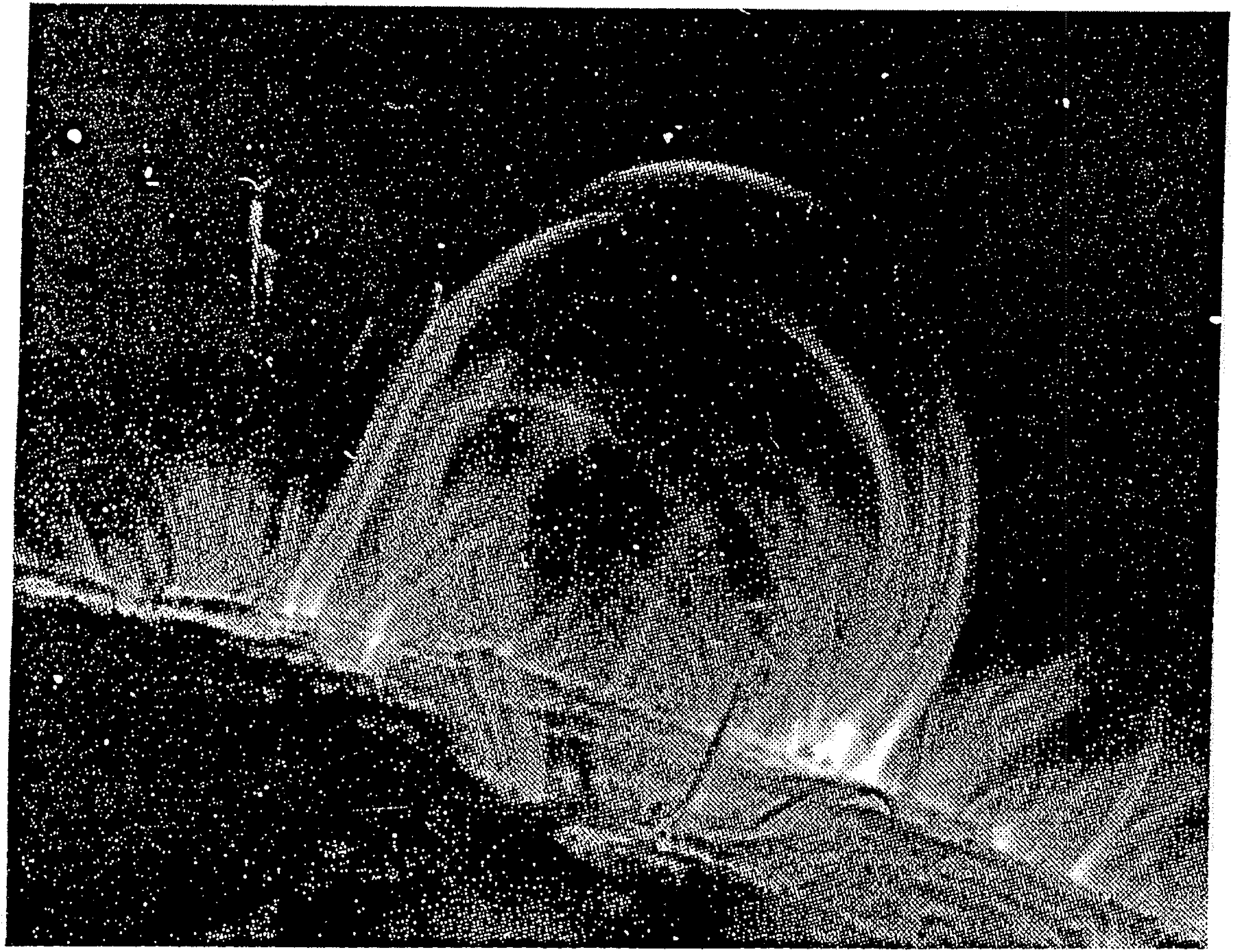

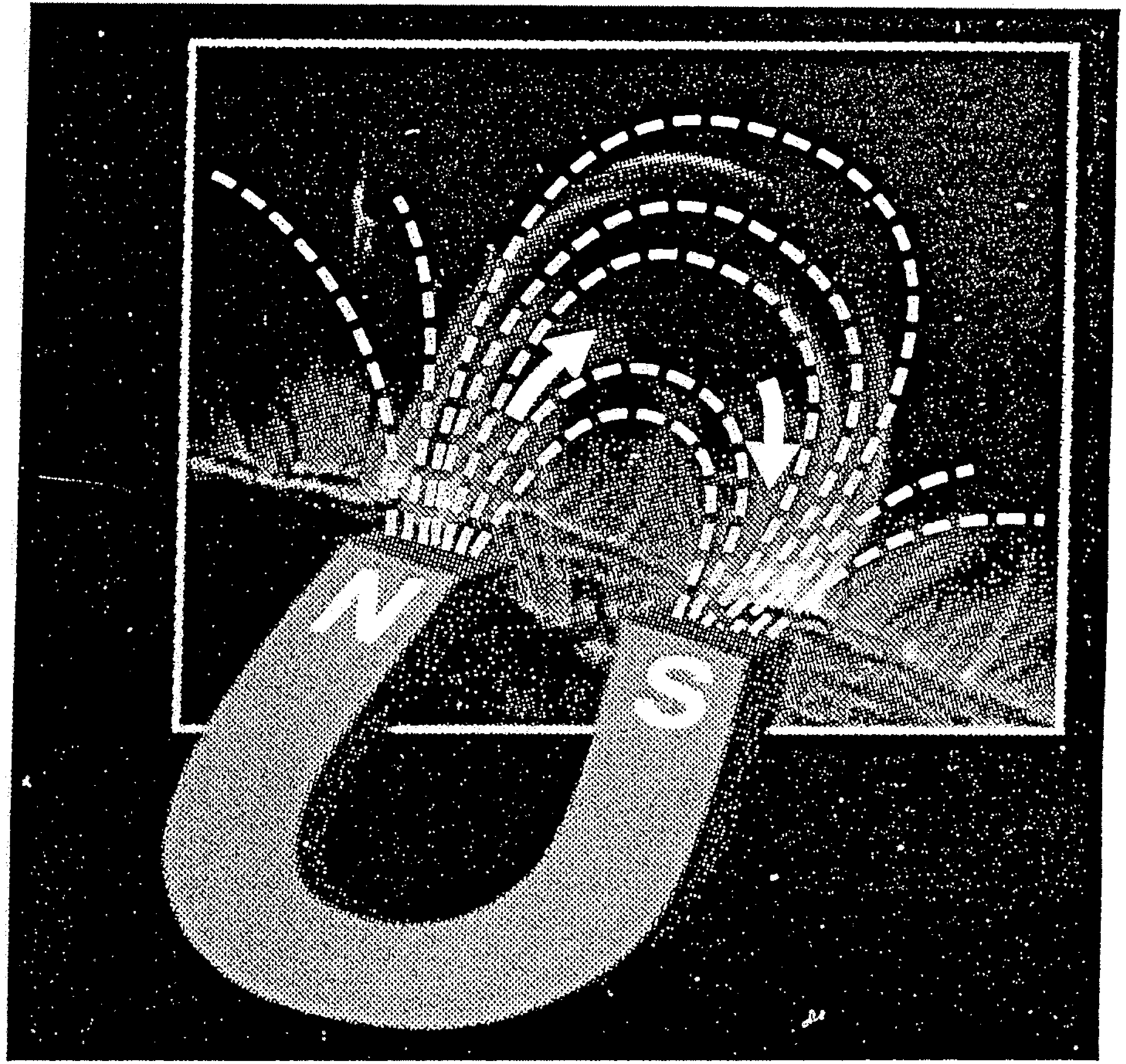
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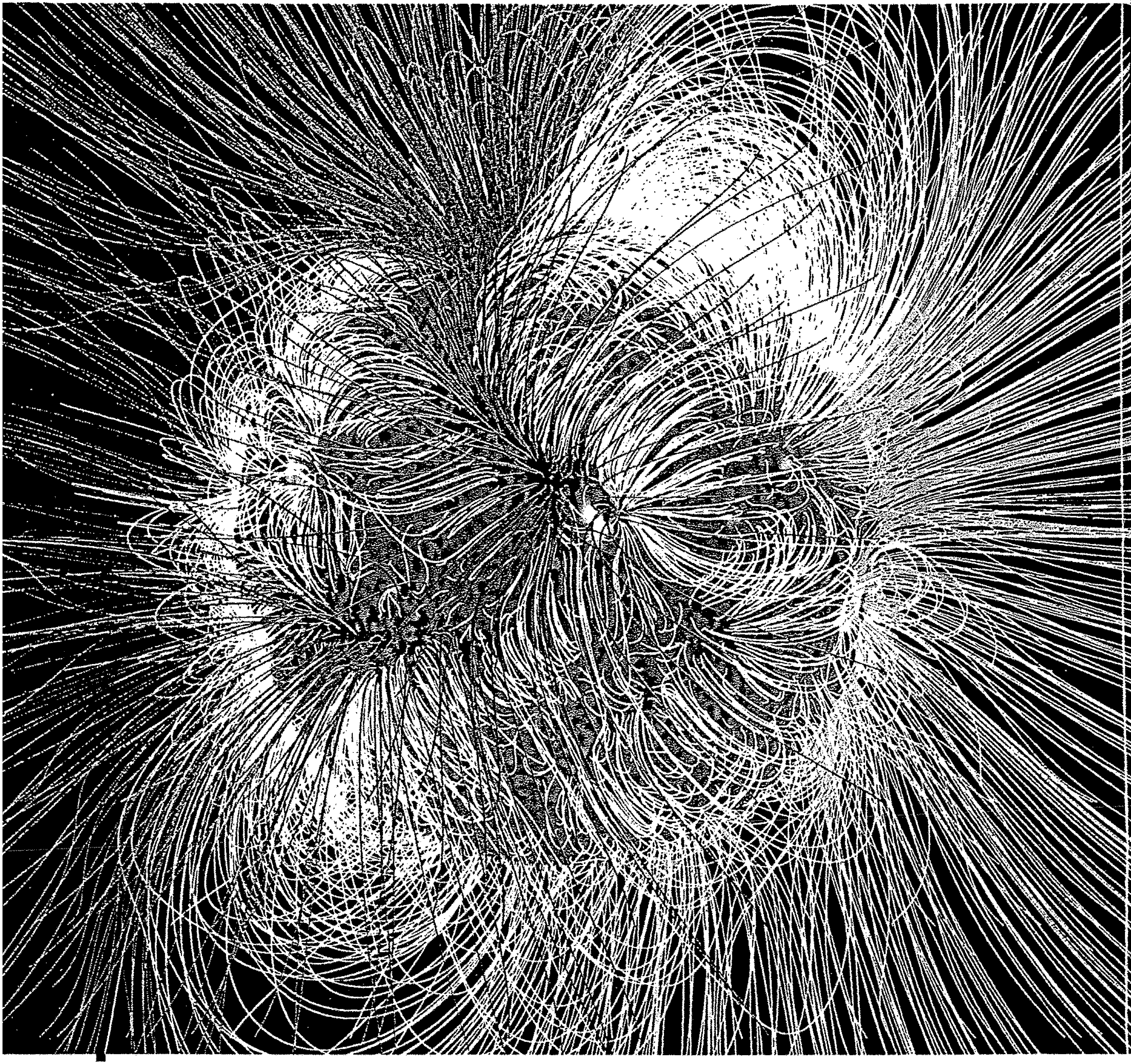

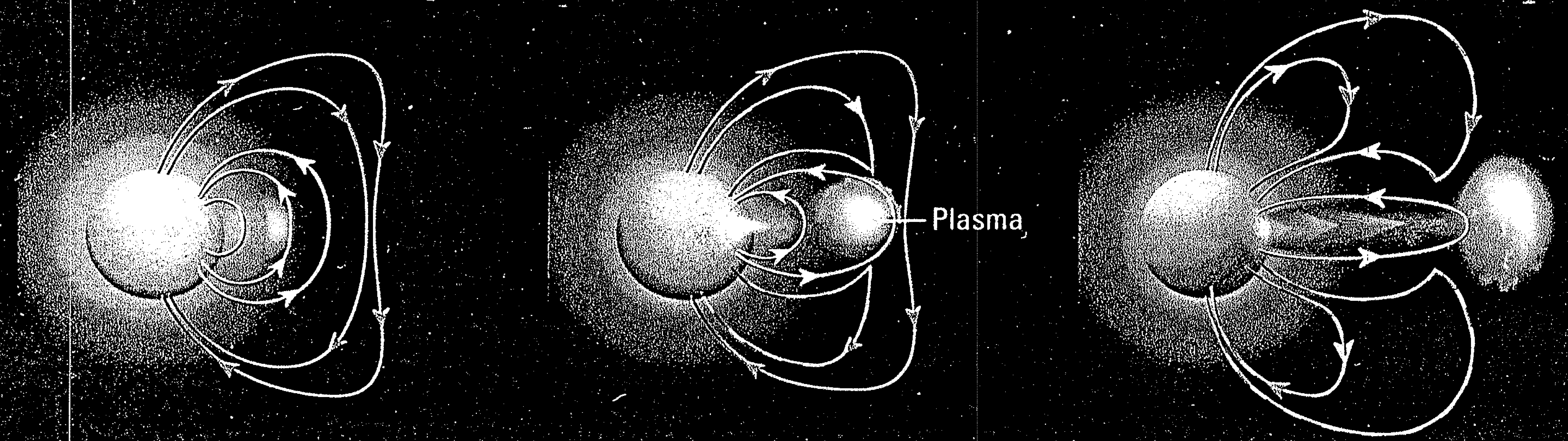

A Storm Erupts

What triggers a CME? Theory holds that coronal loops (blue and yellow) act like a net to restrain energized magnetic fields that are trying to rise, and pressure builds. Constantly in motion, loops can merge in a process called magnetic reconnection, which rips the net. A billion tons of plasma escapes at one to five million miles an hour, growing into a cloud tens of millions of miles wide. Barreling through the slower solar wind, a CME creates a shock wave that can boost its charged plasma and radiation to ultrahigh energies.

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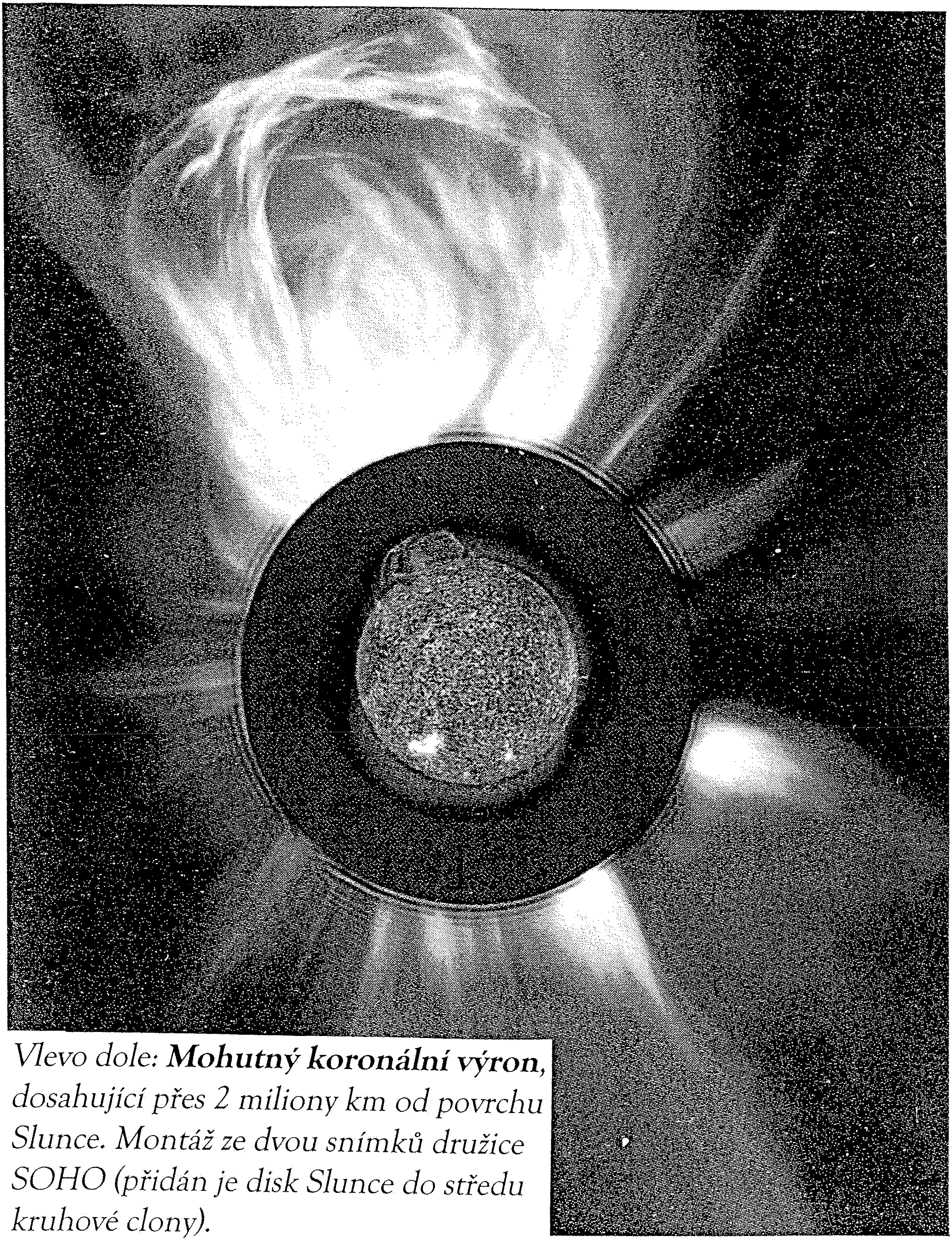
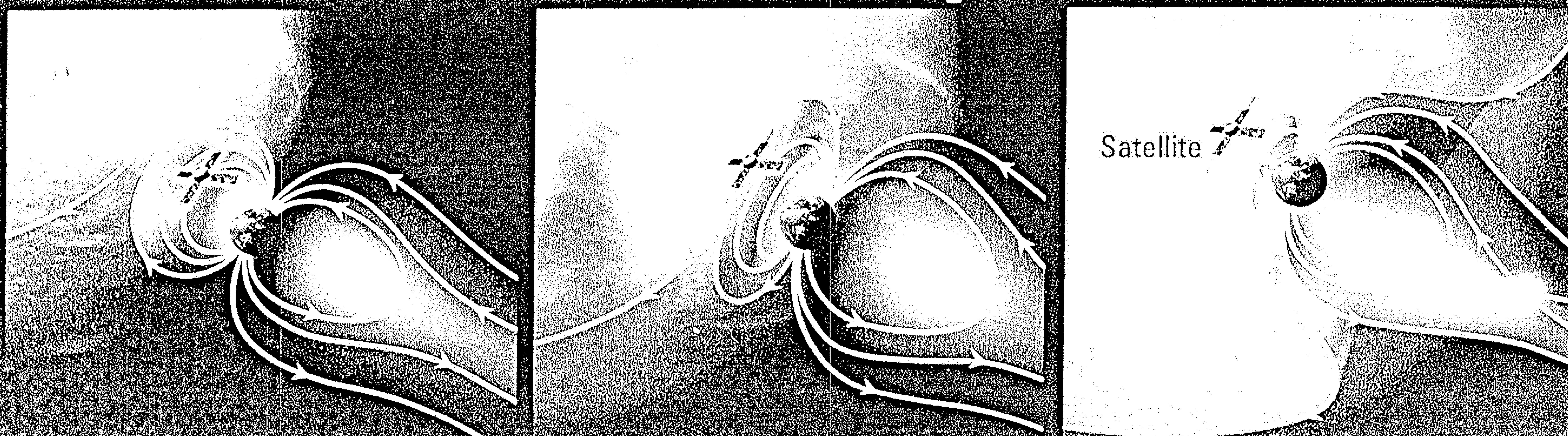
ART BY MOONRUNNER DESIGN. CONSULTANTS: SPIRO K. ANTIOCHOS, NAVAL RESEARCH LABORATORY (NRL); PÅL BREKKE, ESA; BERNHARD FLECK, ESA; PETER T. GALLAGHER INTEGRATED SPACE WEATHER MODELING; STEELE HILL, SOHO/NASA; JAMES A. KLIMCHUK, NRL; GARETH R. LAWRENCE, ROYAL OBSERVATORY OF BELGIUM; JANET G. LUHMA



Vlevo dole: ***Mohutný koronální výron****,*
dosahující přes 2 miliony km od povrchu
Slunce. Montáž ze dvou snímků družice
SOHO (přidán je disk Slunce do středu
kruhové clony).

To see more of the magnetosphere after impact, turn to pages 28-9. For additional details on space weather, see the pull-out supplement.



Earth Takes a Hit

It takes one to three days for a CME to reach us. SOHO and other satellites detect its liftoff, but not until about an hour before impact can we measure how bad it will be. In the worst case (above), a CME carries a southward magnetic orientation, the opposite of Earth's. Such a CME not only compresses our protective magnetosphere (exposing satellites to particles), it also links to our dayside magnetic field and peels back field lines. Then, at the nightside tail, Earth's lines reconnect, driving trillions of watts of power into the upper atmosphere.

SA; PETER T. GALLAGHER, L-3 COMMUNICATIONS GSI; PETER A. GILMAN, HAO/NCAR; CHARLES C. GOODRICH, BOSTON UNIVERSITY, CENTER FOR
GIUM; JANET G. LUHMANN, SPACE SCIENCES LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY; JURI TOOMRE; MICHAEL WILTBERGER, HAO/NCAR


Nightside reconnection
Aurora
Magnetosphere

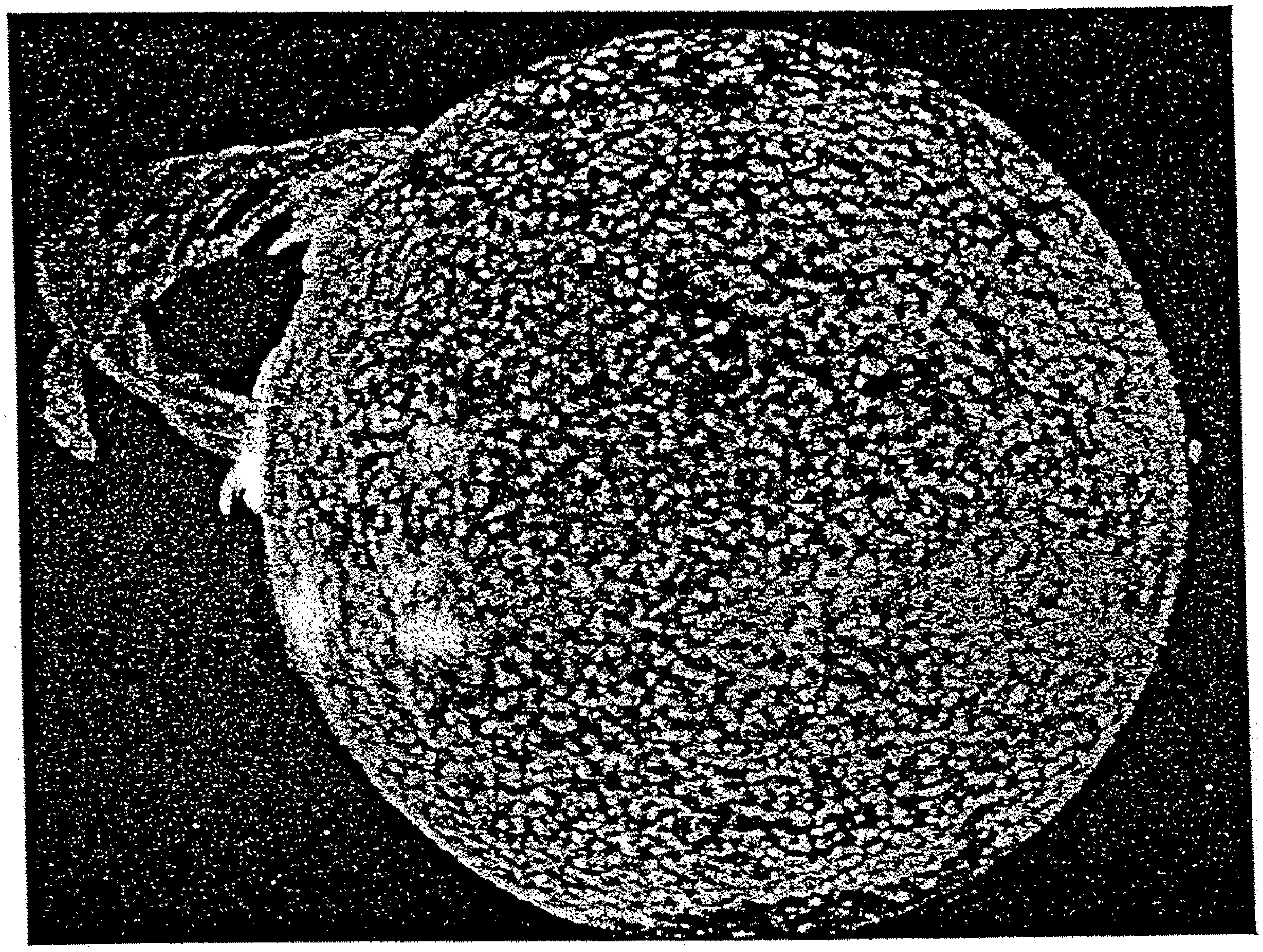


Figure 4.3. The turbulently churning, incandescent surface of the Sun seen in ultraviolet wavelengths; the image exhibits an enormous burst of ionized plasma, a solar flare. Such eruptions characterize sunspot activity and result in magnetic storms on Earth. Why do you suppose this is? (*Source:* Courtesy of NASA.)

Table 22-1

Vital Statistics of Planets

Planet	Diameter (km)	Mass (Earth = 1)	Density (Water = 1)	Gravity (Earth = 1)	Number of satellites	Time for one rotation on axis (Earth days or hours)	Time for one revolution around Sun (Earth years)	Distance from Sun		Composition of atmosphere
								(10^6 km)	(10^6 miles)	
Terrestrial										
Mercury	4835	0.055	5.69	0.38	0	59 days	0.241	57.7	36.8	none
Venus	12,194	0.815	5.16	0.89	0	243 days	0.616	107	66.9	CO_2
Earth	12,756	1.00	5.52	1.00	1	1.00 days	1.00	149	92.6	N_2, O_2
Mars	6760	0.108	3.89	0.38	2	1.03 days	1.88	226	141	CO_2, N_2, Ar
Giant										
Jupiter	141,600	318.	1.25	2.64	15	9.83 hours	11.99	775	482	H_2, He
Saturn	120,800	95.1	0.62	1.17	15	10.23 hours	29.5	1421	883	H_2, He
Uranus	47,100	14.5	1.60	1.03	5	23.00 hours	84.0	2861	1777	H_2, He, CH_4
Neptune	44,600	17.0	2.21	1.50	2	22.00 hours	165.	4485	2787	H_2, He, CH_4
Pluto	14,000?	0.8?	4.2?	?	0	6.39 days	248.	5886	3658	?

Tab. 1: Srovnání paramentrů Slunce, Měsíce, terestrických a vnějších planet (podle různých zdrojů upraveno) Pozn. záporná znaménka u rotace Venuše a Uranu vyjadřují pohyb proti směru rotace ostatních planet

charakteristika	Slunce	Merkur	Venuše	Země	Měsíc
vzdálenost od Slunce (10^6 km)	-	58	108	150	-
hmotnost (Země = 1)	343 000	0,06	0,81	1	0,01
průměrná hustota (g/cm^3)	1,4	5,4	5,2	5,5	3,3
průměr (km)	696 000	2 440	6 052	6 378	1 738
oběh kol. Slunce (zem. rok = 1)	-	0,24	0,62	1	-
rotace kolem osy (dny)	27	59	- 243	1	27,3
úklon oběžné dráhy (orbity) vzhledem k Zemi (ve stupních)	-	7	3,4	0	* 23
úklon rovníku vzledem k orbitě	7	2	177	23	6
počet známých měsíců	-	0	0	1	-
hlavní složky atmosféry	-	-	CO_2,	N_2, O_2	-
tíhové zrychlení na rovníku (m/s^2)		2,78	8,6	9,78	1,62

charakteristika	Mars	Jupiter	Saturn	Uran	Neptun	Pluto
vzdálenost od Slunce (10^6 km)	228	778	1 427	2 870	4 497	5 900
hmotnost (Země = 1)	0,11	318	95	14,6	17,2	0
průměrná hustota (g/cm^3)	3,9	1,3	0,7	1,2	1,7	< 1.7
průměr (km)	3 394	71 400	60 000	25 900	24 750	1 900
oběh kol. Slunce (zem. rok = 1)	1,88	11,9	29,5	84	164	248
rotace kolem osy (dny)	1,03	0,4	0,43	-0,89	0,53	6,4
úklon oběžné dráhy (orbity) vzhledem k Zemi (ve stupních)	1,9	1,3	2,5	0,8	1,8	17,2
úklon rovníku vzledem k orbitě	25	3	27	97	29	122
počet známých měsíců	2	14	10	5	2	1 ?
hlavní složky atmosféry	CO_2	H_2, He	H_2, He	H_2, He, CH_4	H_2, He, CH_4	?
tíhové zrychlení na rovníku (m/s^2)	3,72	22,88	9,05	7,77	11	0,4

Planet	Diameter (km)	Mass (Earth = 1)	Density (Water = 1)	Gravity (Earth = 1)	Number of satellites	Time for one rotation on axis (Earth days or hours)	Time for one revolution around Sun (Earth years)	Distance from Sun (10^6 km)	Distance from Sun (10^6 miles)	Composition of atmosphere
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Pluto	14,000?	0.8?	4.2?	?	0	6.39 days	248.	5886	3658	?


Oberfläche: Methan-Eis
Pluto
Neptun
Atmosphäre: Wasserstoff, Ammoniak, Methan
flüss. molek. Wasserstoff
Eise
Silik.+Met.
Pluto
5910 Mio. km
Atmosphäre: Wasserstoff, Ammoniak, Methan
flüss. molek. Wasserstoff
Uranus
Eise
Silik.+Met.
Neptun
4496 Mio. km
Saturn
Atmosphäre: Wasserstoff, Ammoniak, Methan
flüssiger molekularer Wasserstoff
flüssiger metallischer Wasserstoff
Eise
Silikate u. Metalle
Jupiter
Atmosphäre: Wasserstoff, Ammoniak, Methan
flüssiger molekularer Wasserstoff
flüssiger metallischer Wasserstoff
Silikate u. Metalle
Uranus
2870 Mio. km
25000 km
Mars
Atmosphäre: Kohlendioxid
Kruste: mafische Gesteine
Mantel: Magnesium-Eisen-Silikate
Kern: Eisen + Eisensulfid + Magnetit (Fe_3O_4)
Erde
Atmosphäre: Sauerstoff + Stickstoff
Kruste: Granit, Gneis, Granulite, Gabbroide, Basalt
Mantel: Magnesium-Eisen-Silikate
äußerer Kern: Eisen + Eisenoxid (flüssig)
innerer Kern: Eisen + Nickel (fest)
Saturn
1427 Mio. km
Venus
Atmosphäre: Kohlendioxid + Stickstoff
Kruste: basaltisch u. evtl. auch granitisch
Mantel: Magnesium-Eisen-Silikate
Kern: Eisen + Nickel
Jupiter
778 Mio. km
Asteroiden
Mars
Erde
Venus
Merkur
Merkur
Atmosphäre: keine
Kruste: basaltisch
Mantel: Magnesium-Eisen-Silikate
Kern: Eisen (teilweise flüssig ?)

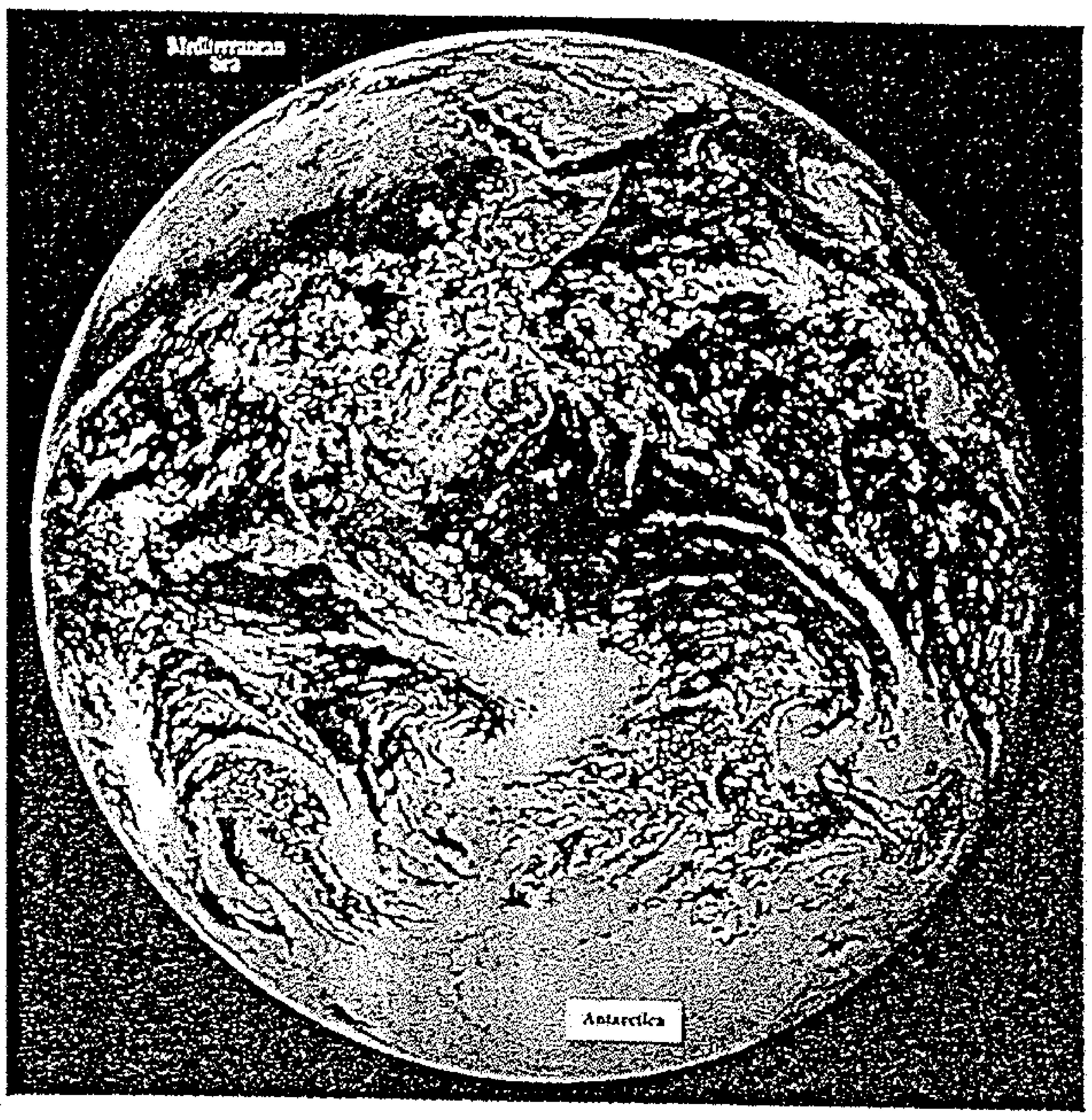
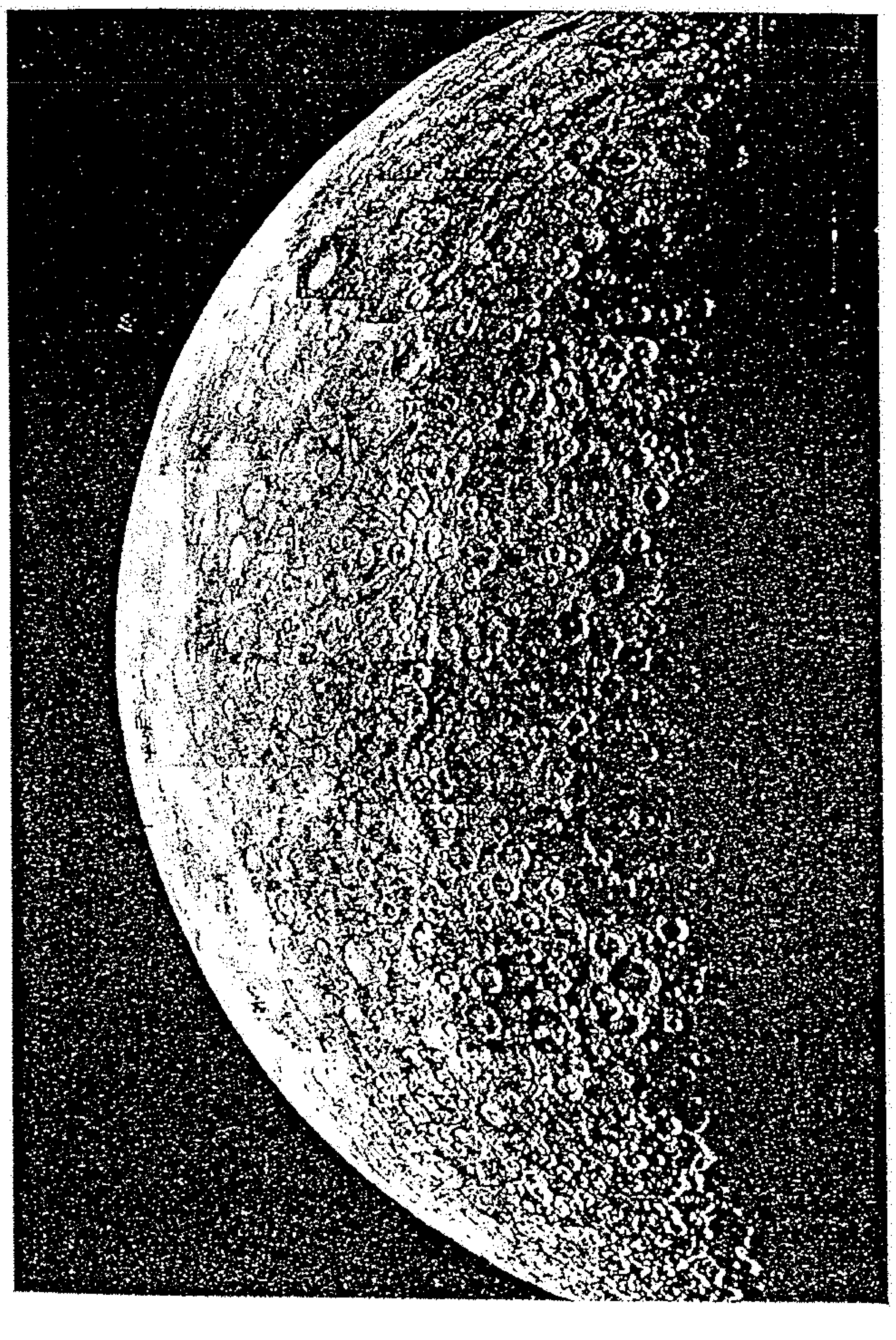


Figure 4.9. Familiar *Apollo 17* image of the Earth, with coverage extending from the Mediterranean Sea to the Antarctic ice cap. The blue planet, as it is sometimes called, contains H_2O in three physical states, solid, liquid, and gaseous (why is this?), dramatically illustrated in this photograph. See color plate section for color version of this figure. (*Source:* Courtesy of NASA.)

Figure 4.5. *Mariner 10* composite mosaic image of Mercury during the spacecraft's closest approach to the innermost planet. The plethora of impact craters can be observed. Why do you suppose there are so many? (*Source:* Courtesy of NASA.)



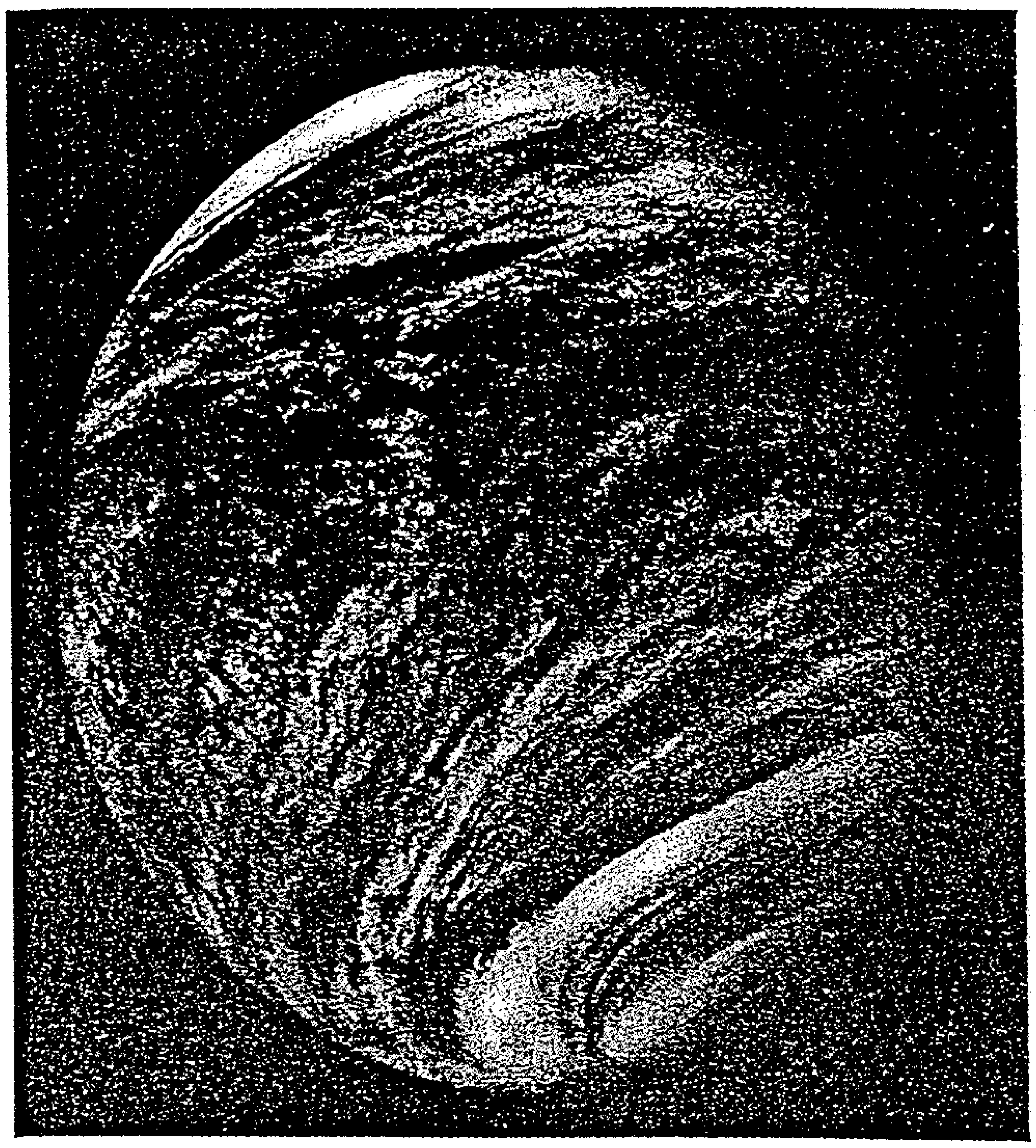
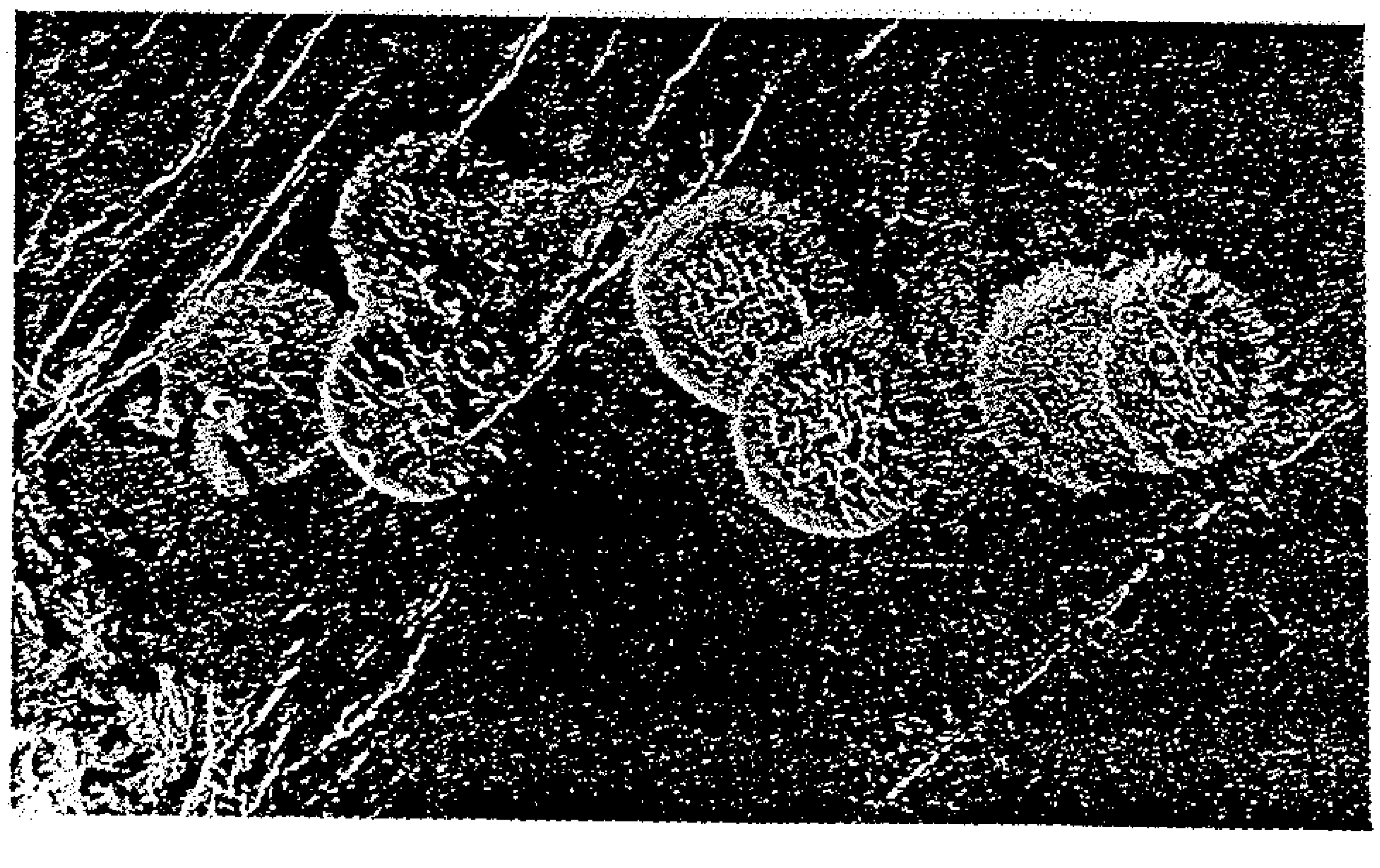


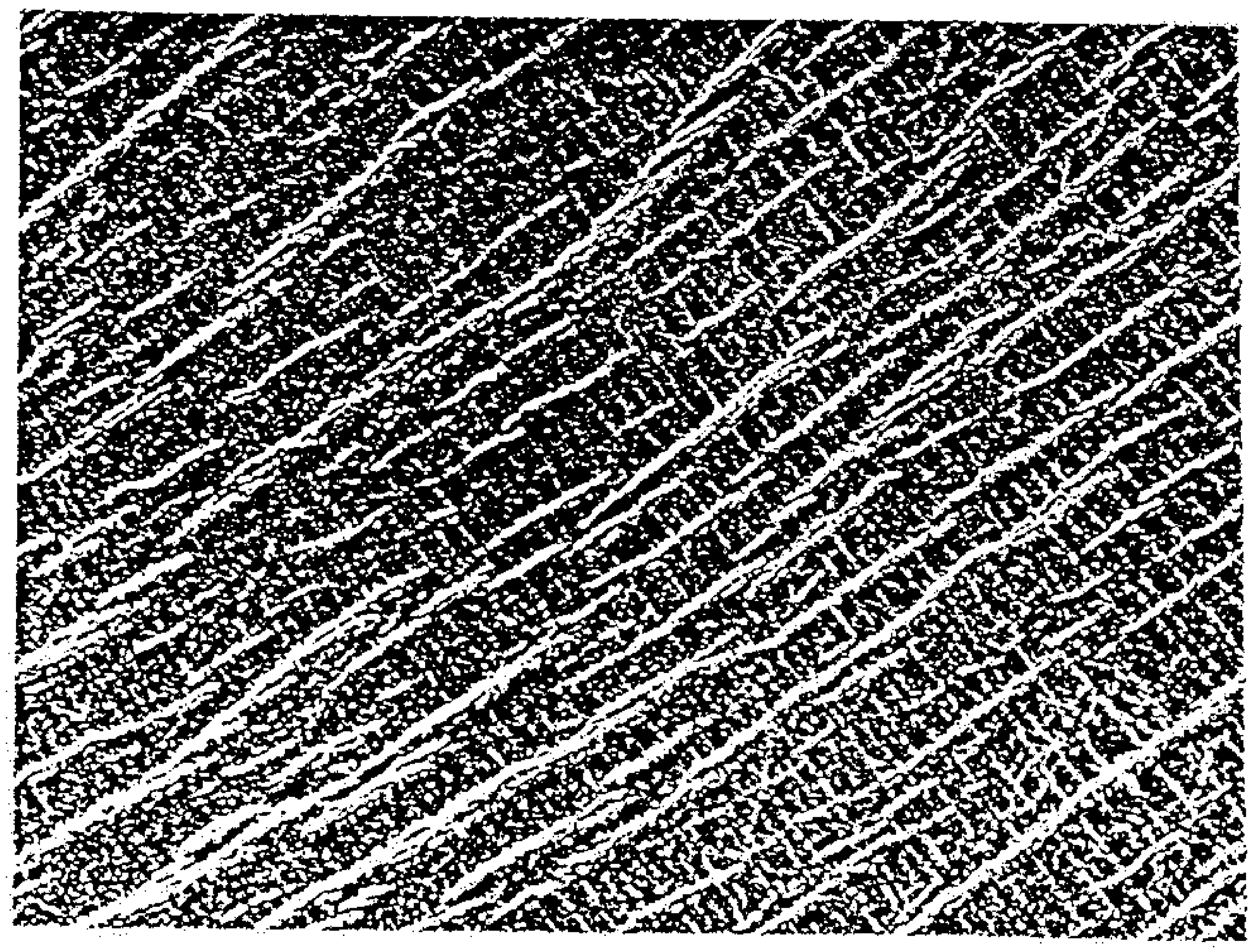
Figure 4.6. *Mariner 10* photograph of Venus, seen from a distance of 720,000 kilometers. The image, shown for ultraviolet wavelengths (a small portion of the entire radiation spectrum), illustrates weather patterns developed in the dense Venusian atmosphere. (*Source:* Courtesy of NASA.)

Figure 4.7. Two radar imagery views and a synthetic composite of Venus, as determined by the *Magellan* spacecraft mission. (A) Fractured, pancake-like magma domes on Venus, approximately 25 kilometers in diameter; they appear to be similar to rhyolite domes on Earth. (B) Planar terrain on Venus, riven by two sets of intersecting fractures. (C) Topography of Venus; highlands stand slightly above lowlands, but relief is not as pronounced as on Earth. (*Source:* Courtesy of NASA.)

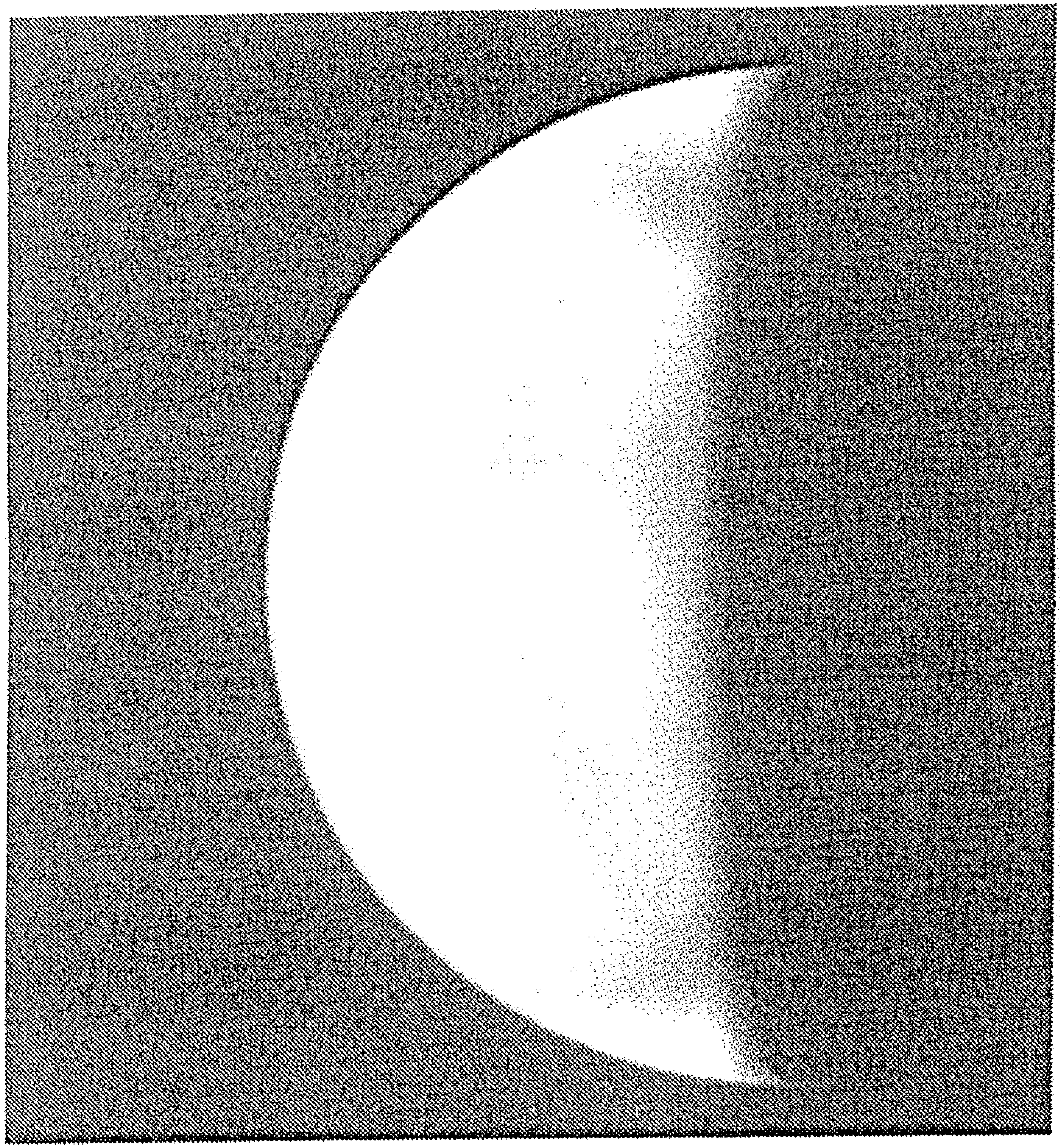
(A)

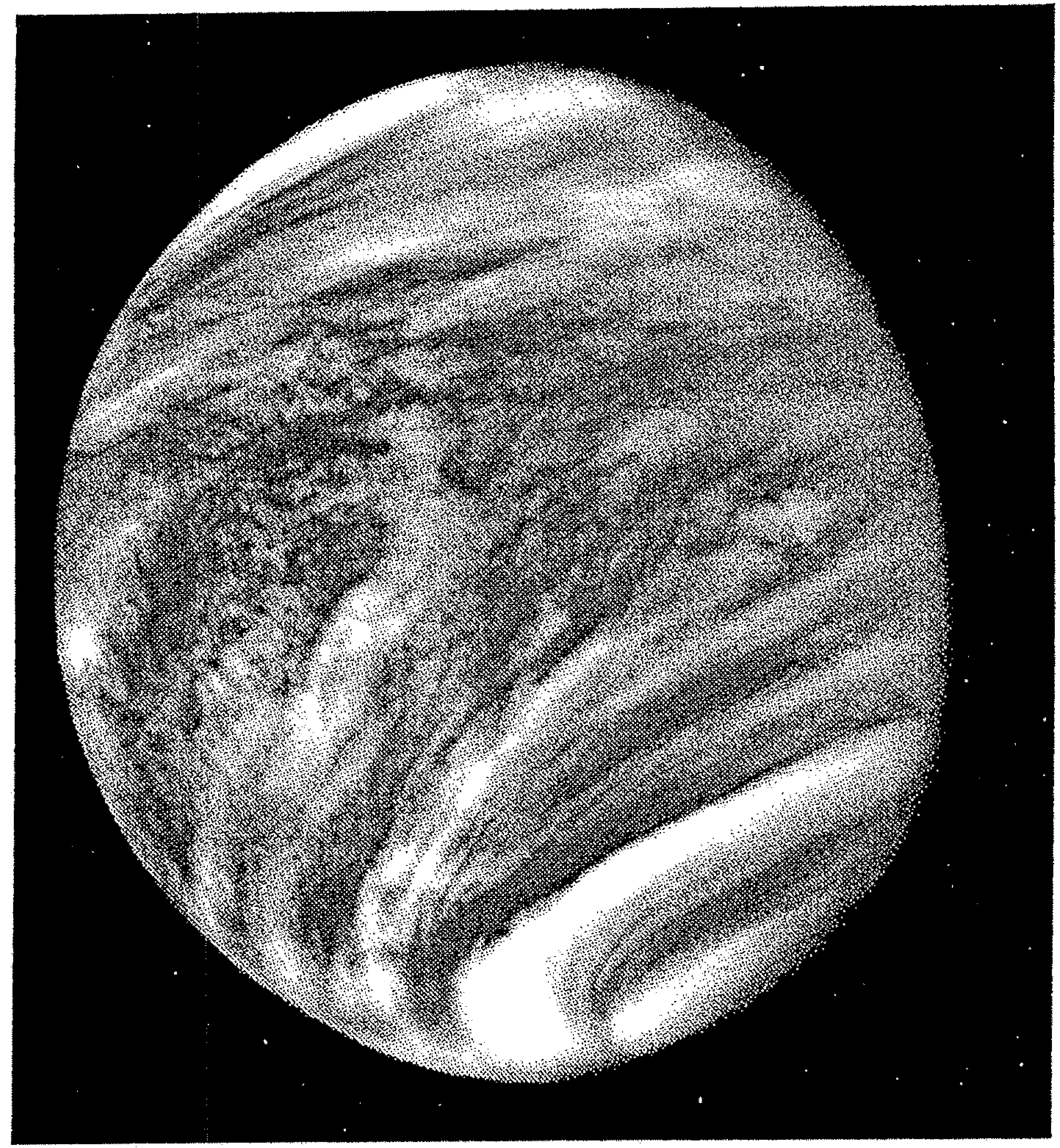


(B)

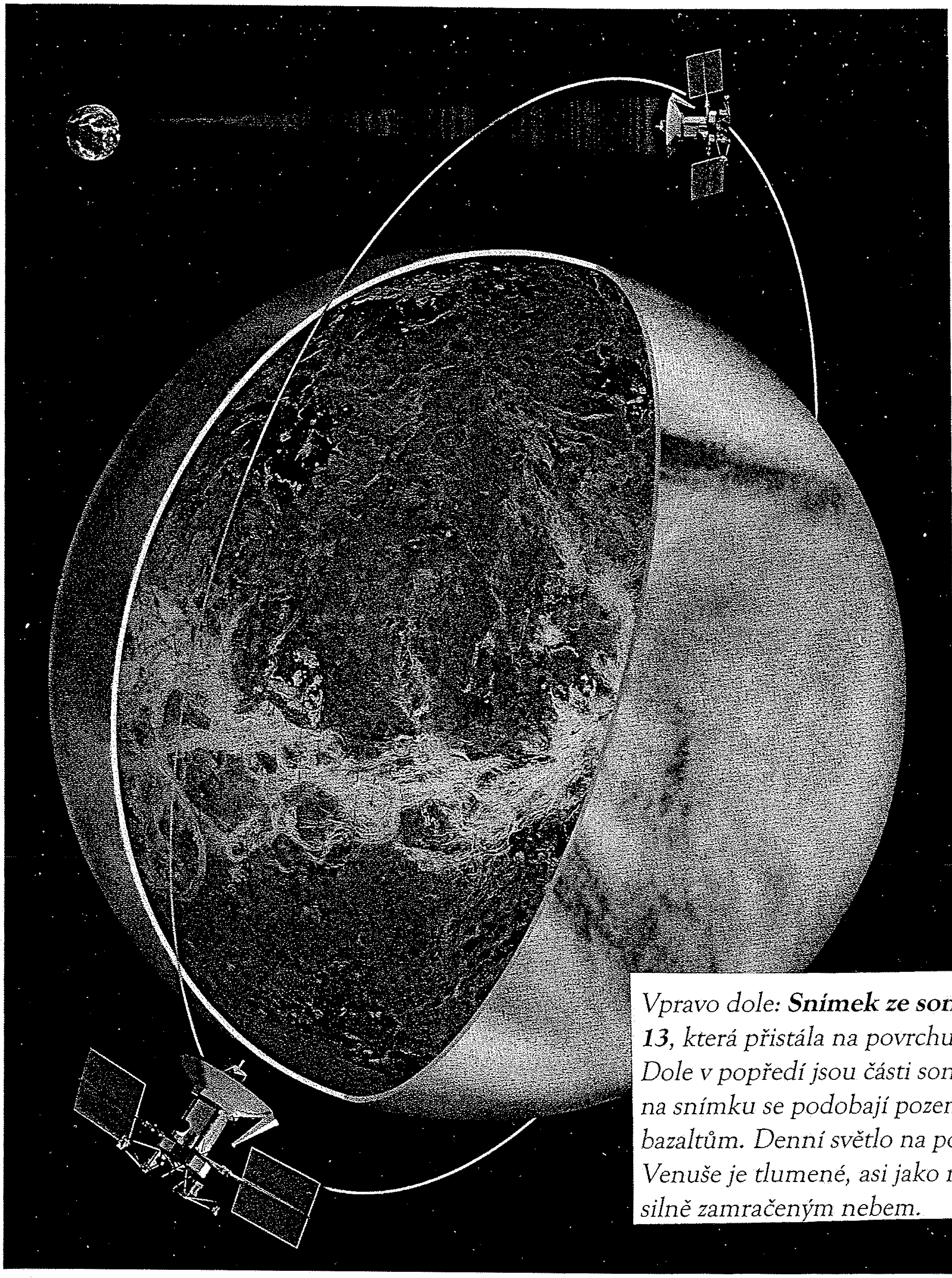


Monet
40°
Gluck
Derzhavin
Holbein
Antoniadi Dorsum
Ts'ai Wen-chi
Wren
Melville
20°
Rodin
Abu Nuwas
Li Po
Moliere
Asvaghosa
Lermontov
Giotto
Chajkovskij
Haystack Vallis
Handel
Al-Jahiz
20°
Donne
Lu Hsun
0°
40°
Mistral
Homer
60°
Thákur
Rudaki
Titian
Byron
Brunelleschi
Dvorák
Kuiper
Murasaki
Hitomaro
Imhotep
Mahler
-20°
Kenko
Balagtas
Renoir
Dario
Ibsen
Arecibo Vallis
Repin
Petrarch
Haydn
Unkei
Neumann
Mirni Rupes
Mofolo
Pigalle
-40°
Chekhov
Nampeyo
Equiano
Rilke
Po Ya
Schubert
Tintoretto
Sotatsu
Andal
Astrolabe Rupes
Discovery Rupes
Africanus Horton
Bramante
Kurosawa
Smetana
Shevchenko
Mendes Pinto
-60°
Hesiod
Khansa
Tsurayuki
Ma Chih-Yuan
Rabelais
Puccini
Pushkin
Callicrates
Holberg
Sei
Horace
Sadi
Boccaccio
-80°

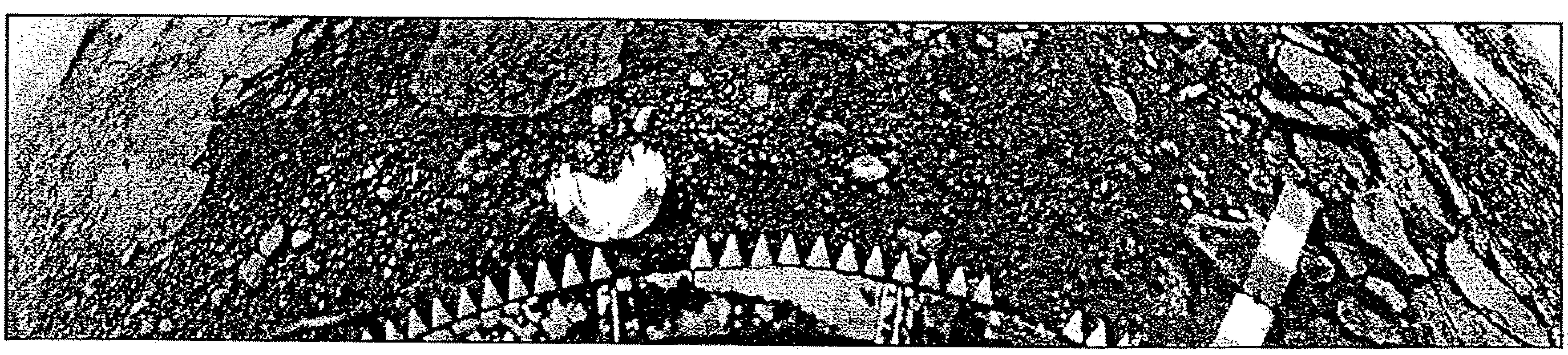




Vlevo: **Vzhled Venuše ve velkém dalekohledu** *(zcela vlevo)* **a na snímku z kosmické sondy,** *která fotografovala planetu v oboru ultrafialového záření (vysvětlení v textu).*



Vpravo dole: ***Snímek ze sondy Venera 13***, *která přistála na povrchu Venuše. Dole v popředí jsou části sondy. Horniny na snímku se podobají pozemským bazaltům. Denní světlo na povrchu Venuše je tlumené, asi jako na Zemi pod silně zamračeným nebem.*

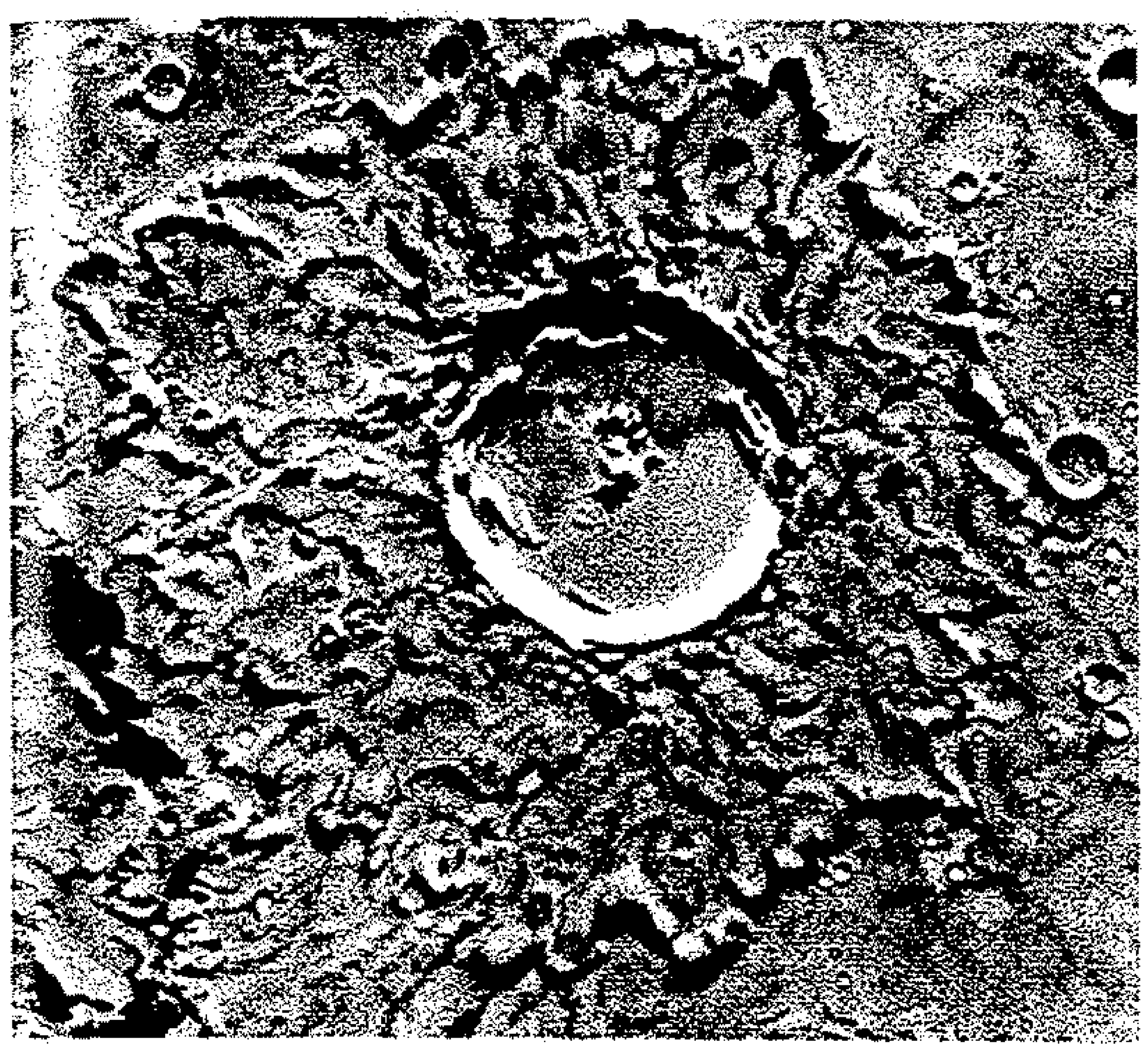


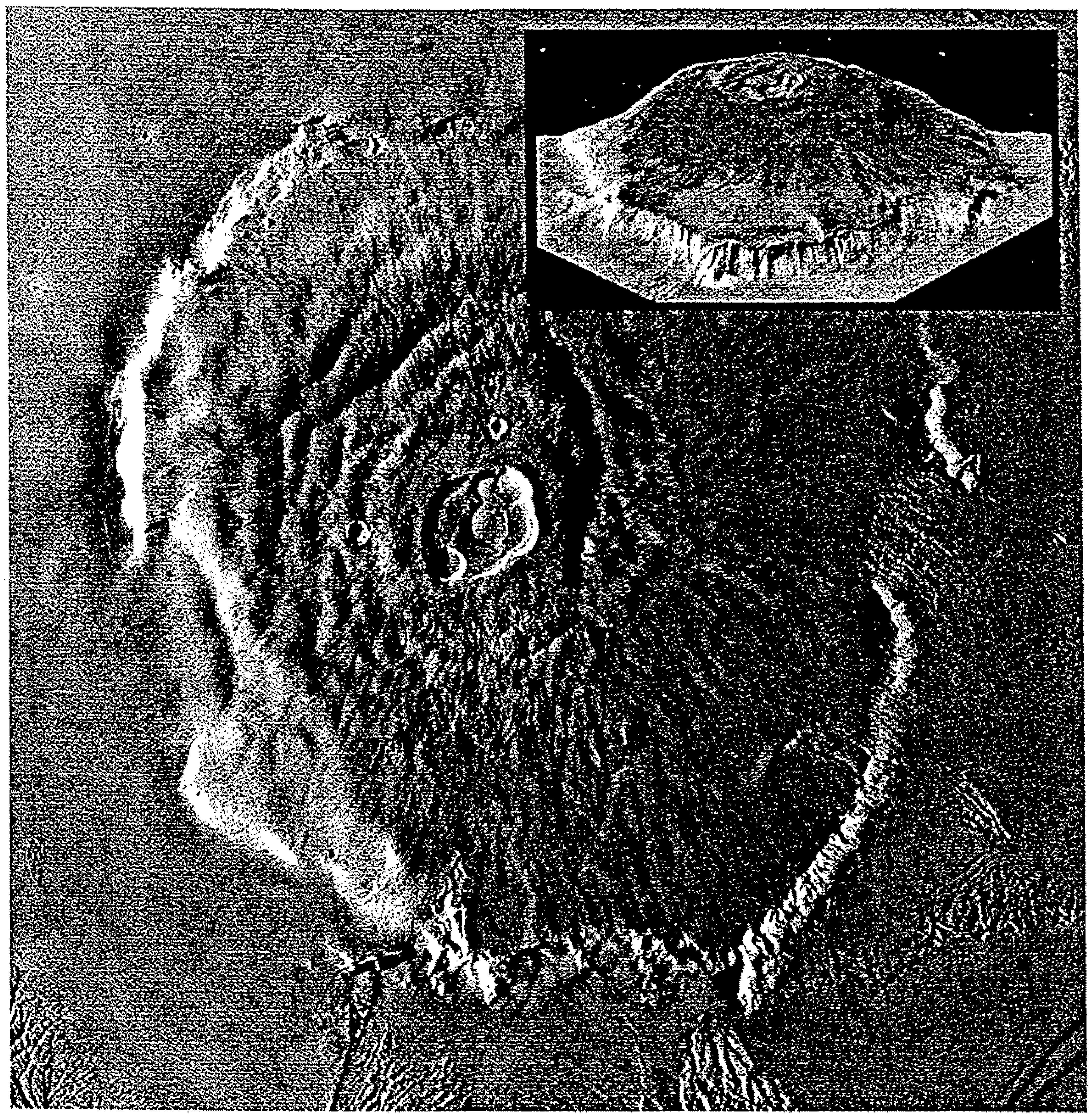

N
60°
30°
0°
-30°
-60°
S
GANIKI PLANITIA
ULFRUN REGIO
Sapas Mons
Ozza Mons
Maat Mons
Dali Chasma
Diana Chasma
Artemis Chasma
INDRA REGIO
NAVKA 180°
90°
120°
210°
240°
E
T E R R A
PLANITIA
7-11
7
5
km
3
2
1
0
-1
-2.5
I S H T A R T E R R A
BETA
Rhea Mons
Theia Mons
REGIO
BEREGHINYA PLANITIA
Tepev Mons
Sif Mons
Gula Mons
Sappho
EISTLA
REGIO
TINATIN
PLANITIA
PHOEBE
REGIO
RUSALKA
PLANITIA
ALPHA
REGIO
Hathor Mons
LAVINIA PLANITIA
THEMIS
REGIO
HELEN
PLANITIA
240°
270°
300°
330°
0
30°
60°

Dole: ***Počítačová rekonstrukce „leteckého" pohledu na malou část povrchu Venuše*** *podle radarových dat ze v pozadí na obzoru vystupuje mohutná sopka. Dohlednost při povrchu je několik desítek kilometrů, jak potvrdily přistávající*

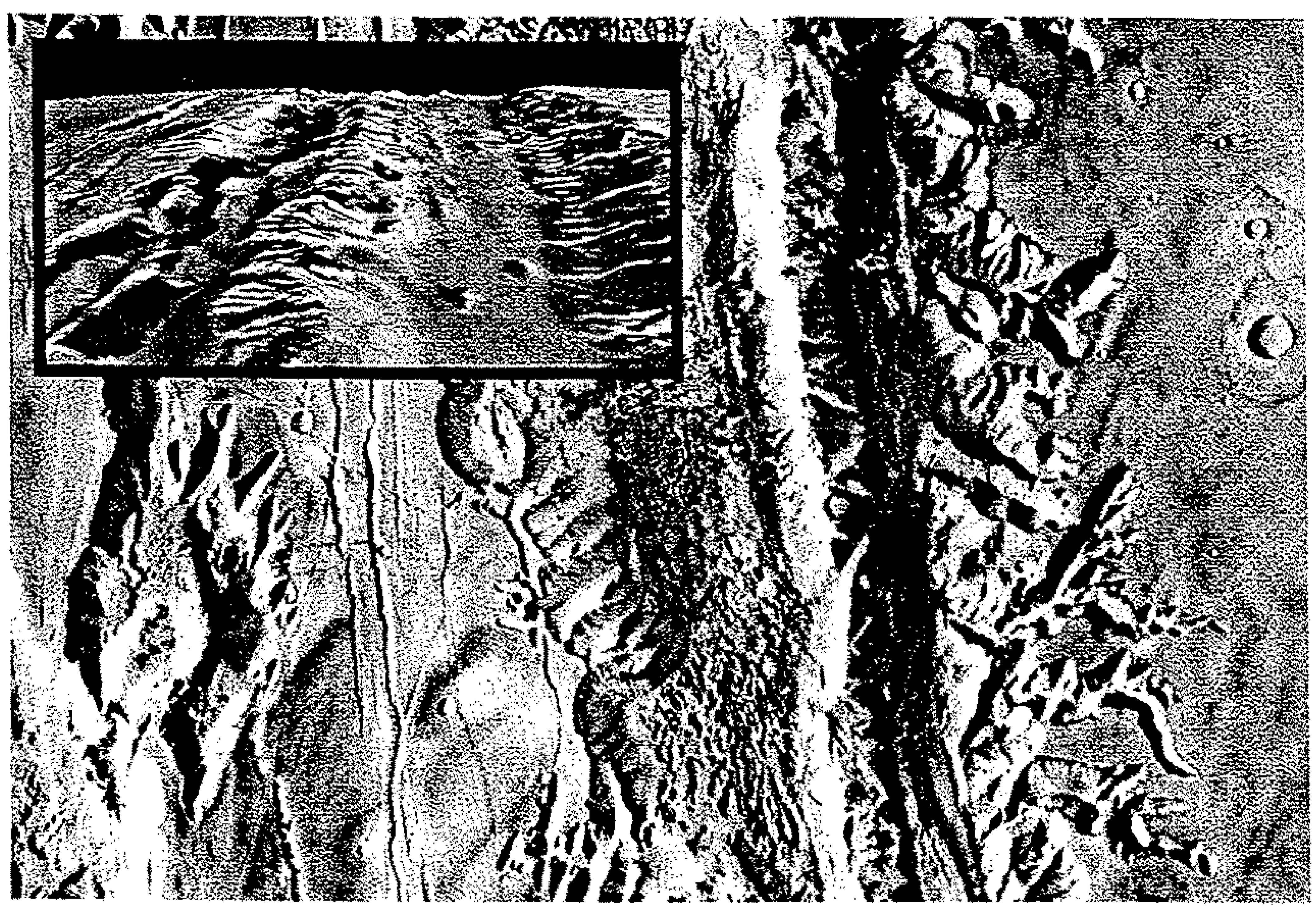

N
80°
80°
70°
70°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
-30°
-40°
-50°
-60°
-70°
-70°
-80°
-80°
150°
120°
90°
60°
30°
0°
S
OLYMPIA PLANITIA
PLANUM BOREUM
Lomonosov
Kunowsky
Scandia Colles
VASTITAS BOREALIS
Milanković
ACIDALIA PLANITIA
Perepelkin
Alba Fossae
Tantalus Fossae
Barabashov
Sklodowska
Alba Patera
Mareotis Fossae
Tempe Fossae
TEMPE TERRA
CHRYSE PLANITIA
Curie
ARABIA
Nilokeras Scopulus
Becquerel
Sharonov
Uranius Tholus
Uranius Patera
Kasei Valles
Viking 1
Mars Pathfinder
McLaughlin
Radau
Olympica Fossae
Ceraunius Fossae
Ceraunius Tholus
Fesenkov
Lunae Dorsa
LUNAE PLANUM
XANTHE TERRA
Trouvelot
Ascraeus Mons
Tharsis Tholus
Sacra Fossae
TERRA
Ulysses Fossae
Galilaei
Crommelin
Pavonis Mons
Biblis Patera
Ulysses Patera
THARSIS MONTES
Hebes Chasma
Mutch
Da Vinci
Hydraotes Chaos
Aram Chaos
Tithonium Chasma
Ophir Chasma
TERRA
TERRA MERIDIANI
Arsia Mons
Candor Chasma
Ius Chasma
Melas Chasma
OPHIR PLANUM
Aureum Chaos
MARGARITIFER TERRA
SYRIA PLANUM
SINAI PLANUM
VALLES MARINERIS
Coprates Chasma
Capri Chasma
Eos Chaos
Pyrrhae Chaos
Margaritifer Chaos
DAEDALIA PLANUM
SOLIS PLANUM
Lassell
Vinogradov
Beer
Ritchey
Holden
Kasimov
Pickering
Lampland
Bond
AONIA TERRA
ICARIA PLANUM
Hale
NOACHIS
Hooke
Arkhangelsky
Vogel
Halley
Hartwig
Porter
Nansen
ARGYRE PLANITIA
Lowell
Galle
Lohse
Hussey
Ross
Green
Chamberlin
Agassiz
Darwin
Maraldi
Heaviside
Schmidt
Phillips
TERRA
Stoney
Lau
Joly
Wegener
Charlier
Reynolds
PLANUM AUSTRALE

Vpravo: **Obrovitá štítová sopka Olympus Mons** o průměru 500 km se vypíná do výšky 24 km nad okolní rovinou. Na vrcholu má kráter (kalderu) o průměru 90 km. Hora je ohraničena 6 km vysokým srázem. Vložený obrázek ukazuje šikmý pohled na vulkán.
Dole: **Dopadový (impaktní) kráter o průměru 20 km.** Vyvržený materiál byl zřejmě tekutý a vytvořil kolem kráteru lem se zdviženými okraji.

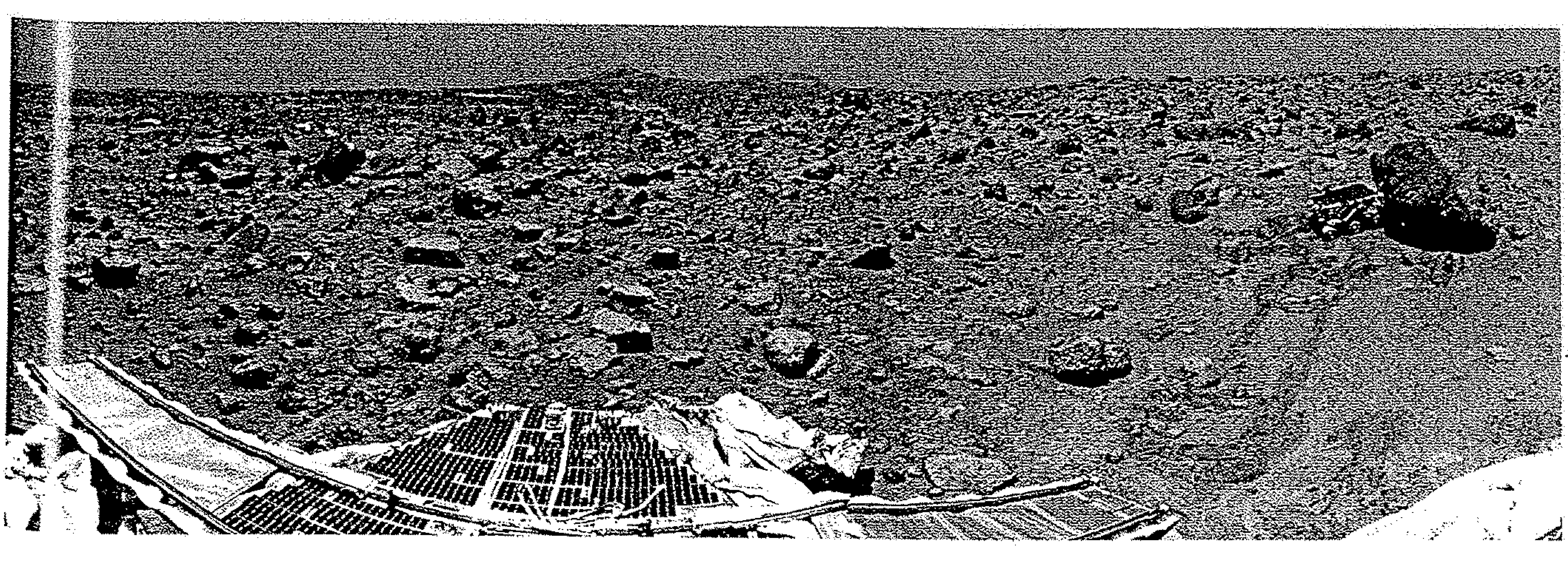




Nahoře: **Asi 60 km dlouhý úsek soustavy kanálů připomínajících vyschlá řečiště.** Zřejmě je kdysi vymodelovala nějaká tekutina, nejspíše voda.



Vpravo nahoře: **Asi 110 km dlouhý úsek gigantické soustavy kaňonů Valles Marineris.** Vložený obrázek vytvořený počítačem názorně ukazuje tvary rozsedlin, nejspíše tektonického původu. Hloubka hlavního kaňonu je 2 až 7 km, celý komplex je dlouhý 4000 km.



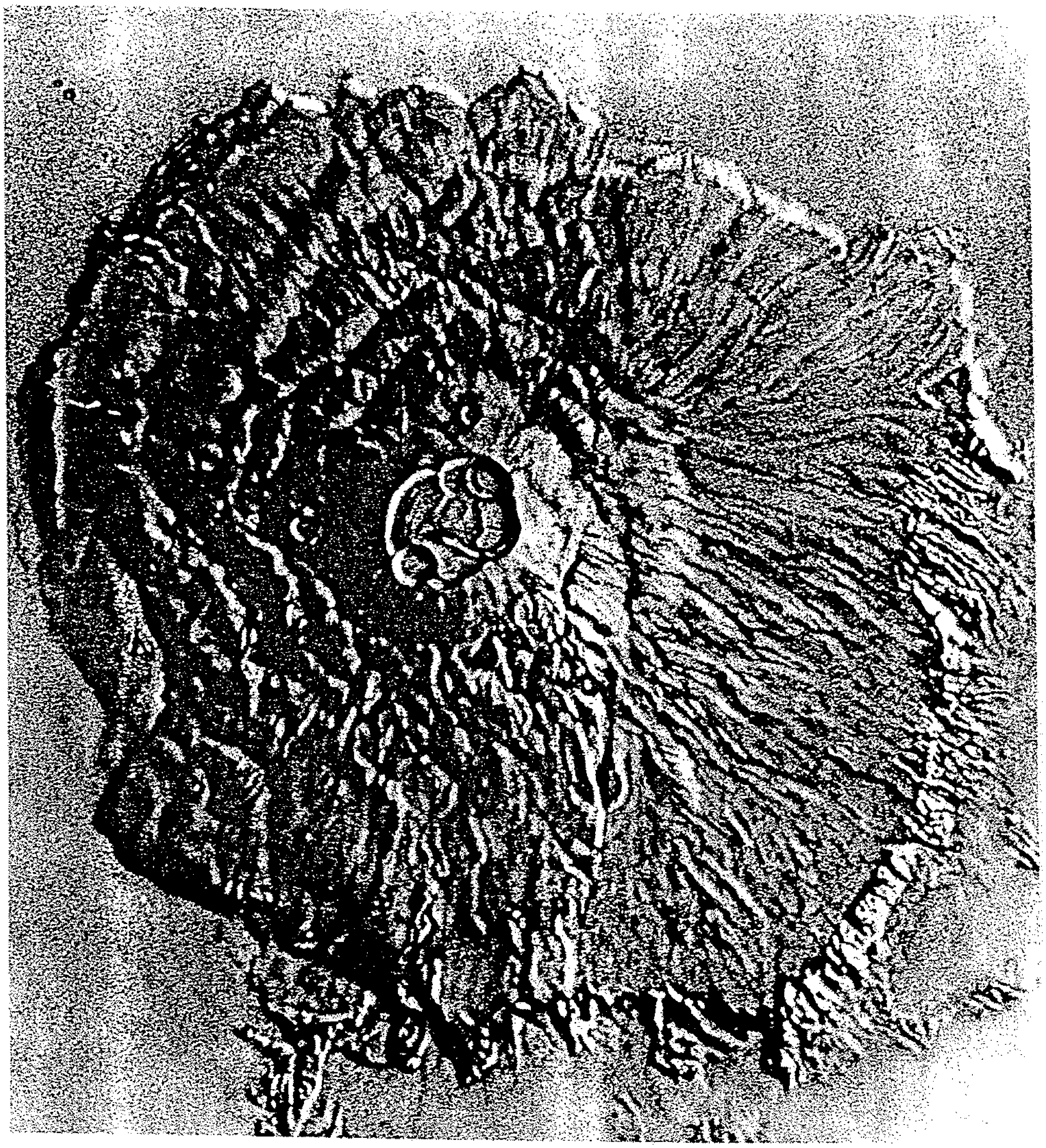
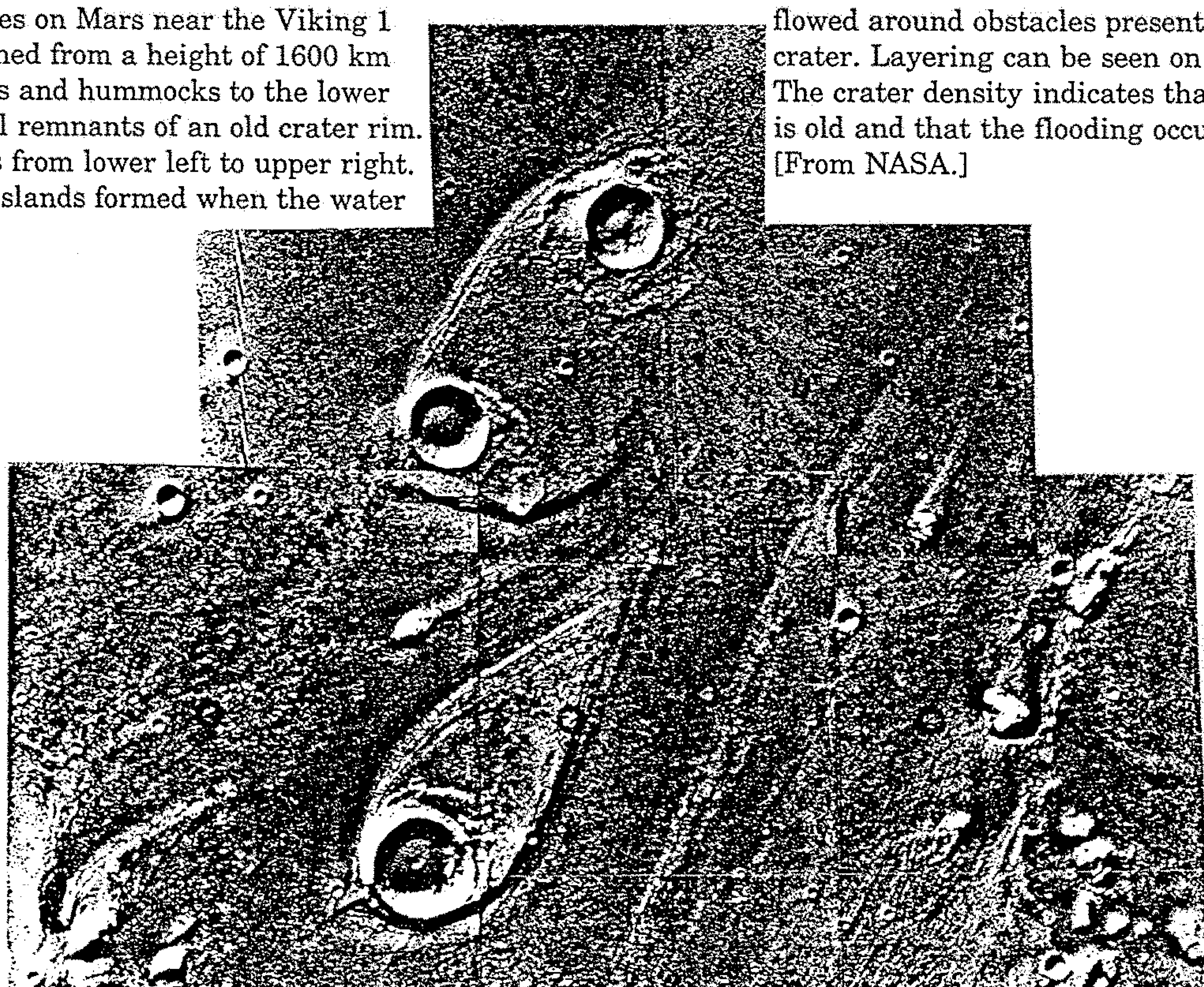


Figure 22-15

Viking 1 photograph of the great Martian volcano, Olympus Mons. The 27-km-high (17 miles) mountain is about 600 km (370 miles) across at the base and would extend from San Francisco to Los Angeles or from Boston to Baltimore. Note the complex, multiple vent, main crater, and the steep cliffs that drop off from the mountain's flanks to the surrounding plain. [From U.S. Geological Study and NASA.]

Figure 22-16

Some erosional features on Mars near the Viking 1 lander site photographed from a height of 1600 km (992 miles). The knobs and hummocks to the lower right are the erosional remnants of an old crater rim. The flow of water was from lower left to upper right. The teardrop-shaped islands formed when the water flowed around obstacles presented by an existing crater. Layering can be seen on the sides of the island. The crater density indicates that the floodplain surface is old and that the flooding occurred a long time ago. [From NASA.]



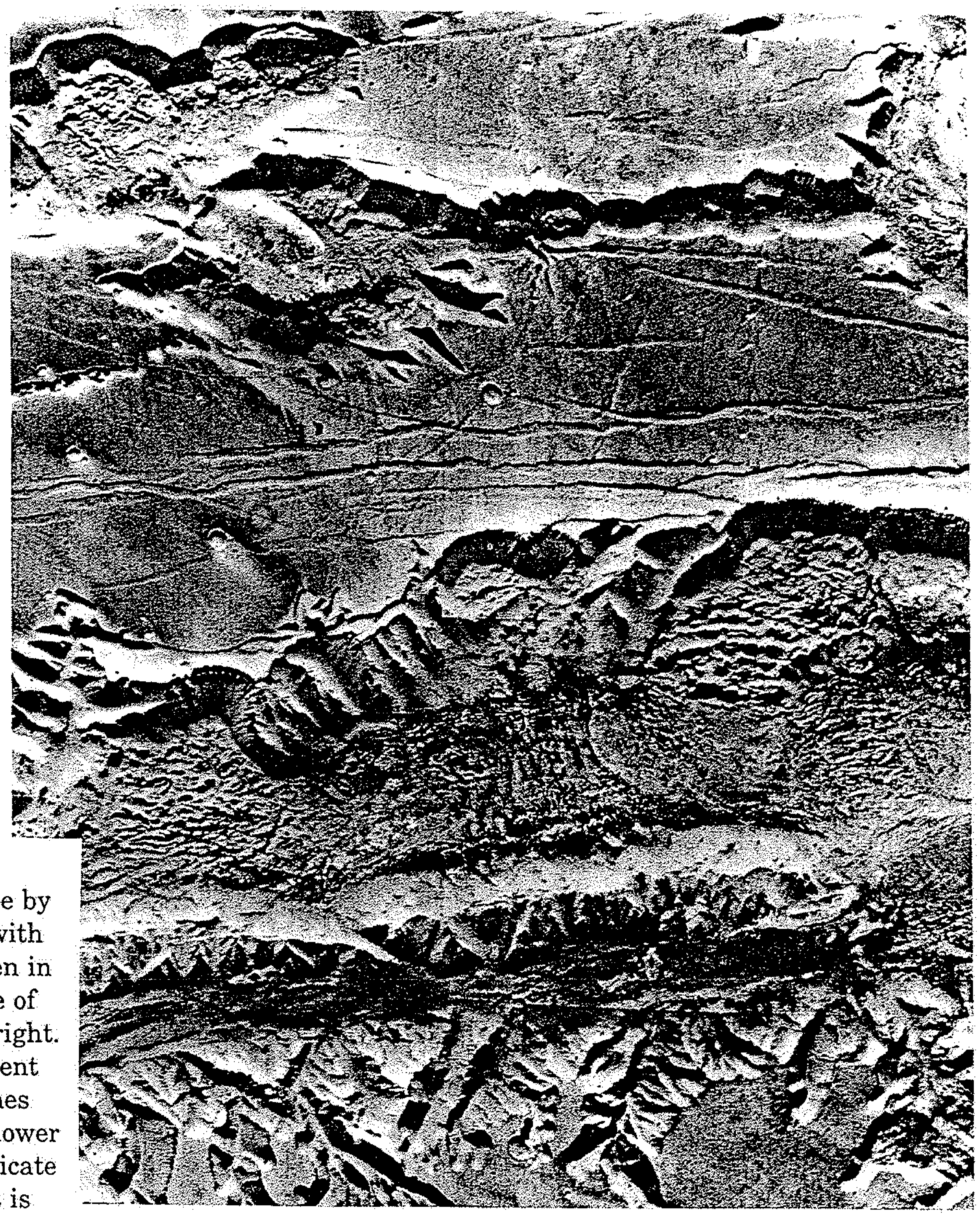
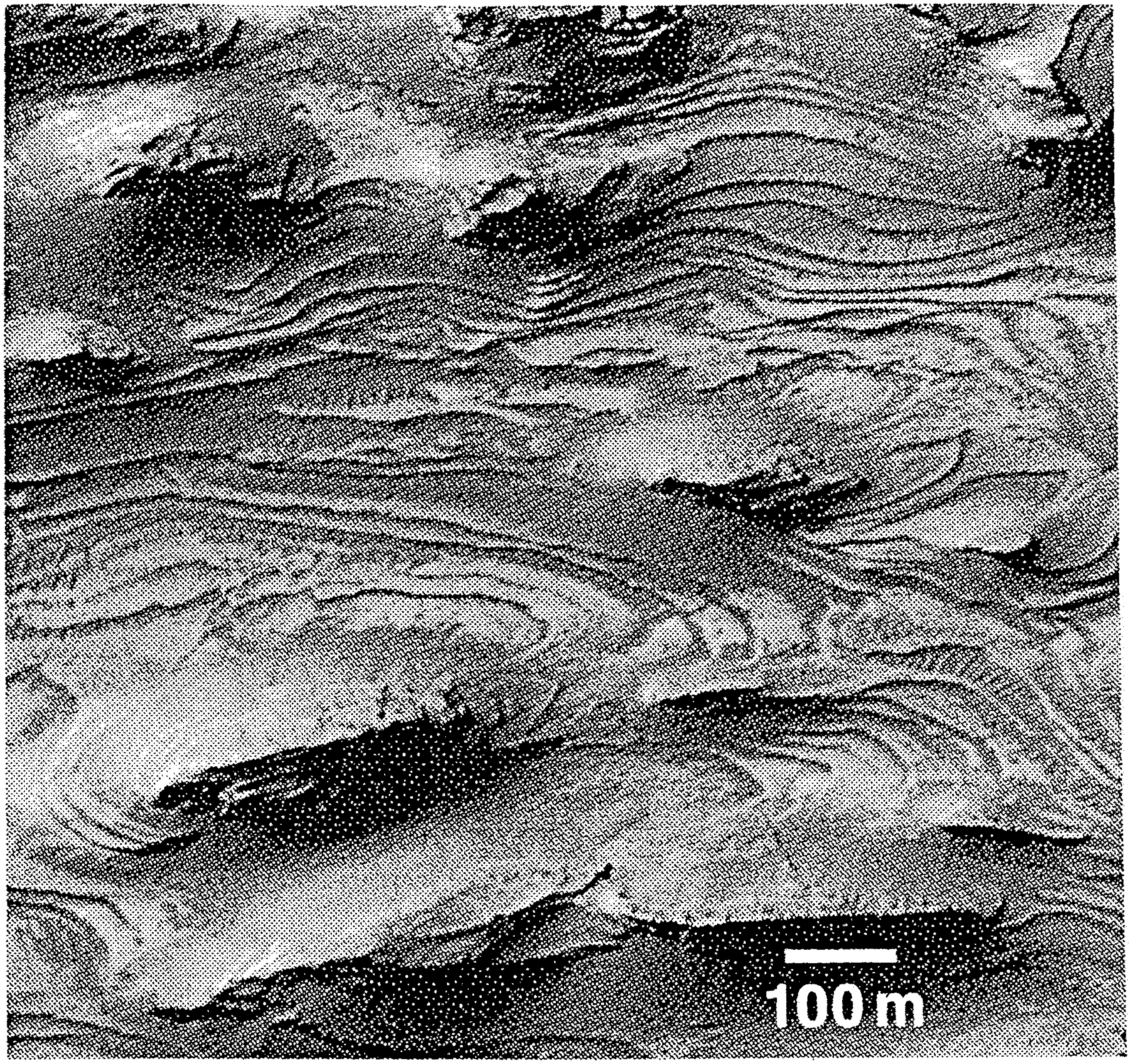


Figure 22-17

Viking 1 photomosaic of the enormous canyon Valles Marineris from a height of 4200 km (2600 miles); north is to the top. The principal canyon crosses the bottom half of the picture in an east–west direction. The northern wall of the main canyon shows several large landslides. The series of branching channels cut into the plateau on the bottom from the south wall may have been formed by slow erosion as a result of the release of groundwater. Other branches of the canyon are visible at the top. [From NASA.]

Figure 22-18

This spectacular picture of the Martian landscape by the Viking 1 lander shows a dune field littered with boulders, a view remarkably similar to many seen in the deserts of Earth. The picture covers an angle of 100°, looking northeast at left and southeast at right. The sharp dune crests indicate that the most recent windstorms capable of moving sand over the dunes blew in the general direction from upper left to lower right. Small deposits downwind of rocks also indicate this wind direction. The large boulder at the left is about 8 m (25 ft) from the spacecraft and measures about 1 m by 3 m (3 ft by 10 ft). The meteorology boom, which supports Viking's miniature weather station, cuts through the picture's center. The sun rose 2 hours before the picture was taken and is about 30° above the horizon near the center of the picture. [From NASA.]



Vlevo: ***Snímek vrstev sedimentárních (usazených) hornin v kaňonu Candor Chasma*** *patří k nejvýznamnějším objevům ze sondy Mars Global Surveyor. Na planetě bylo nalezeno mnoho podobných oblastí s četnými vrstvami sedimentů, jež s velkou pravděpodobností kdysi vznikaly v mělkých mořích a jezerech. Není však vyloučeno, že to mohou být vrstvy usazeného prachu, kdysi navátého větrem. Na snímcích ze sondy Mars Global Surveyor byly v r. 2000 objeveny i možné známky přítomnosti podpovrchové vody a jejího prosakování ve srázech a svazích; k potvrzení tak zásadních nálezů pokračují výzkumy. Také měření ze sondy Mars Odyssey 2001 svědčí o příměsi vodního ledu v regolitu (půdě Marsu), zejména na jih od 60° jižní areografické šířky.*

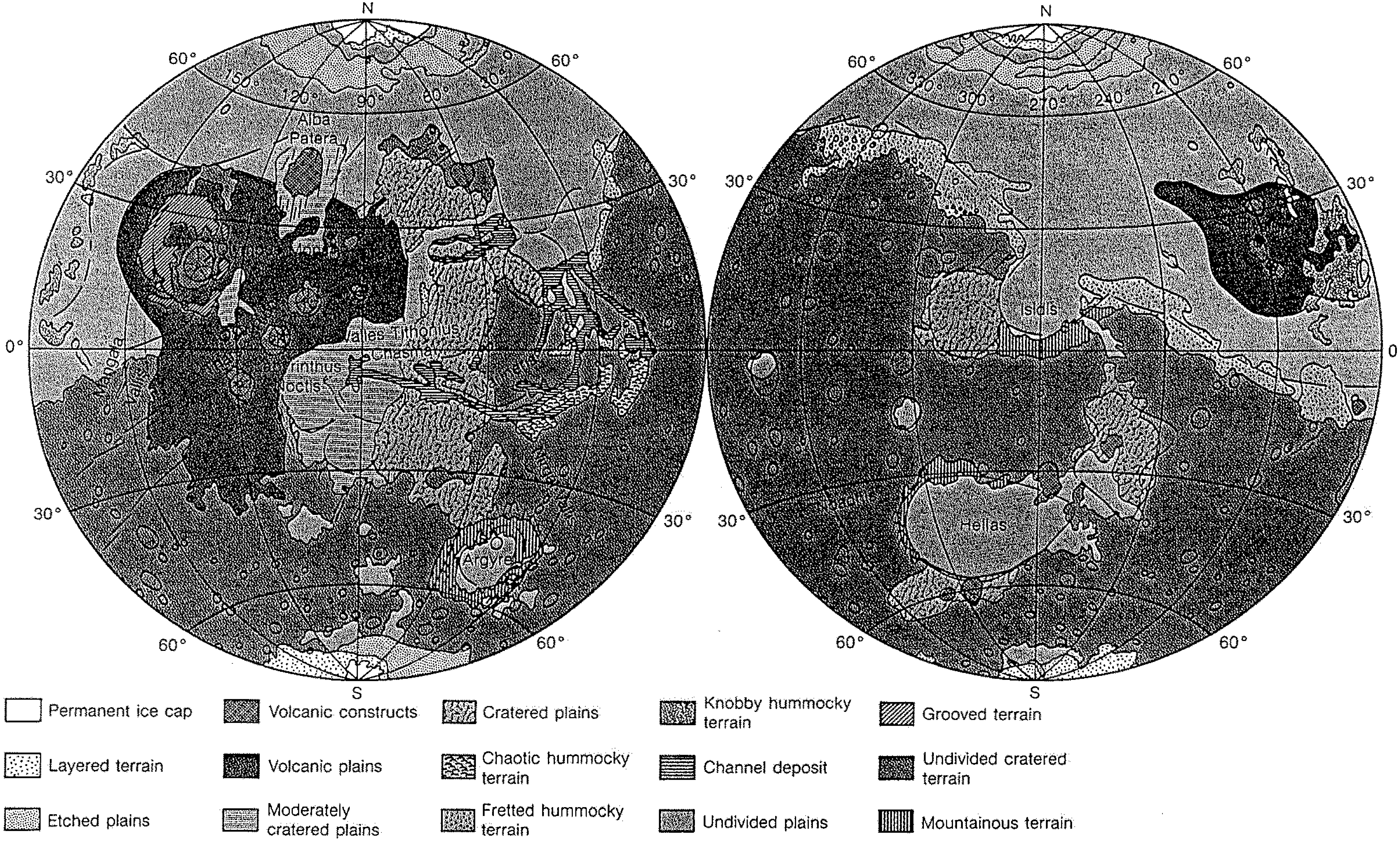


Figure 22-14

Geological features of Mars based on Mariner 9 pictures. Permanent ice caps are mostly water and CO_2 ice. The oldest and most cratered terrain occurs in the Southern Hemisphere. Large volcanoes and sparsely cratered volcanic plains predominate in the Northern Hemisphere. Channel deposits are flood features. The absence of mountain chains, transform faults, linear troughs, and ridges indicates a stable crust without plate tectonics. [From "Mars" by J. B. Pollack.]

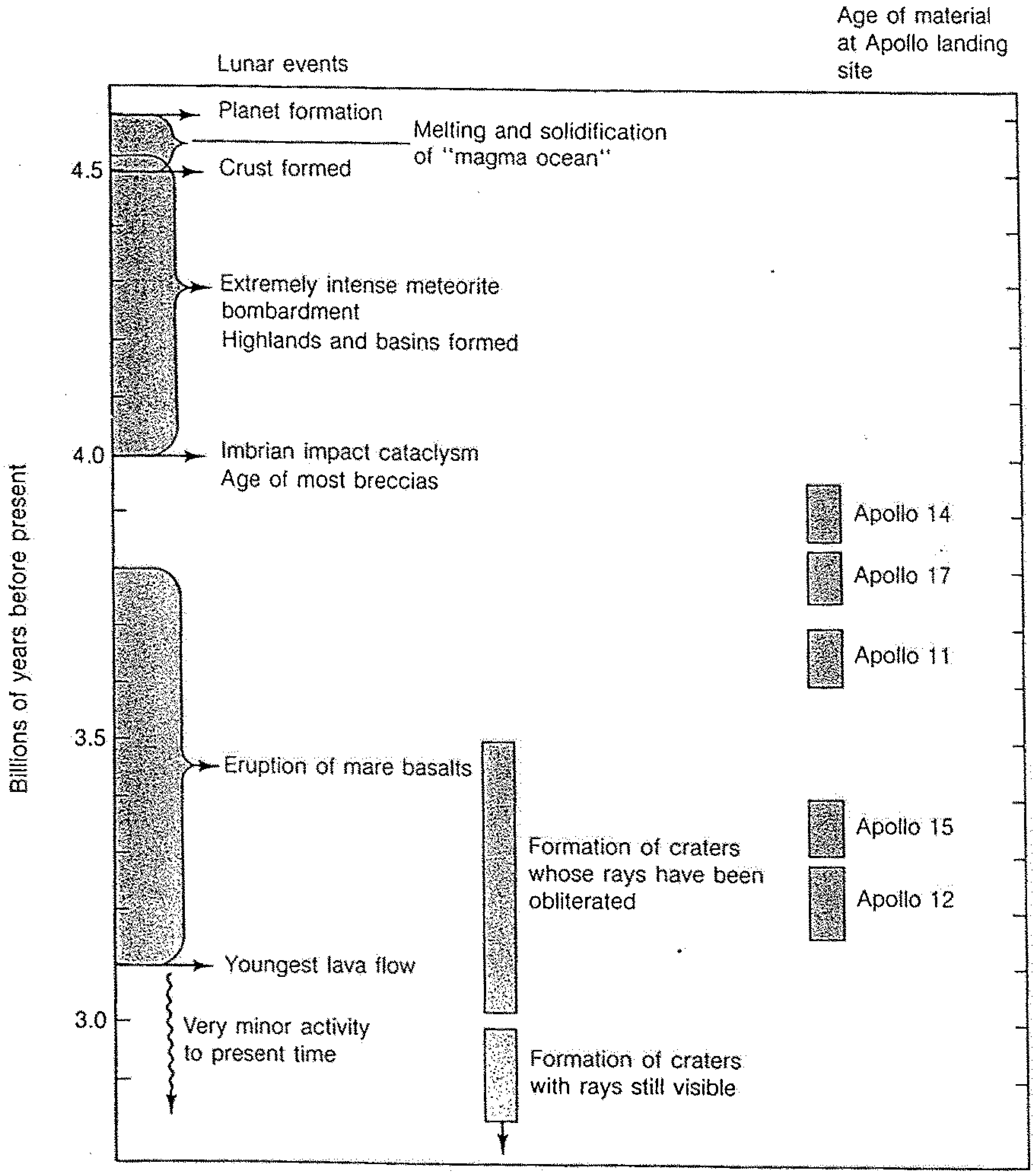


Figure 22-9

Lunar chronology and ages of material at Apollo landing sites. The Moon's early history was dominated by differentiation, impact bombardment, and mare volcanism. The Moon has been "geologically dead" for the last 3 billion years.

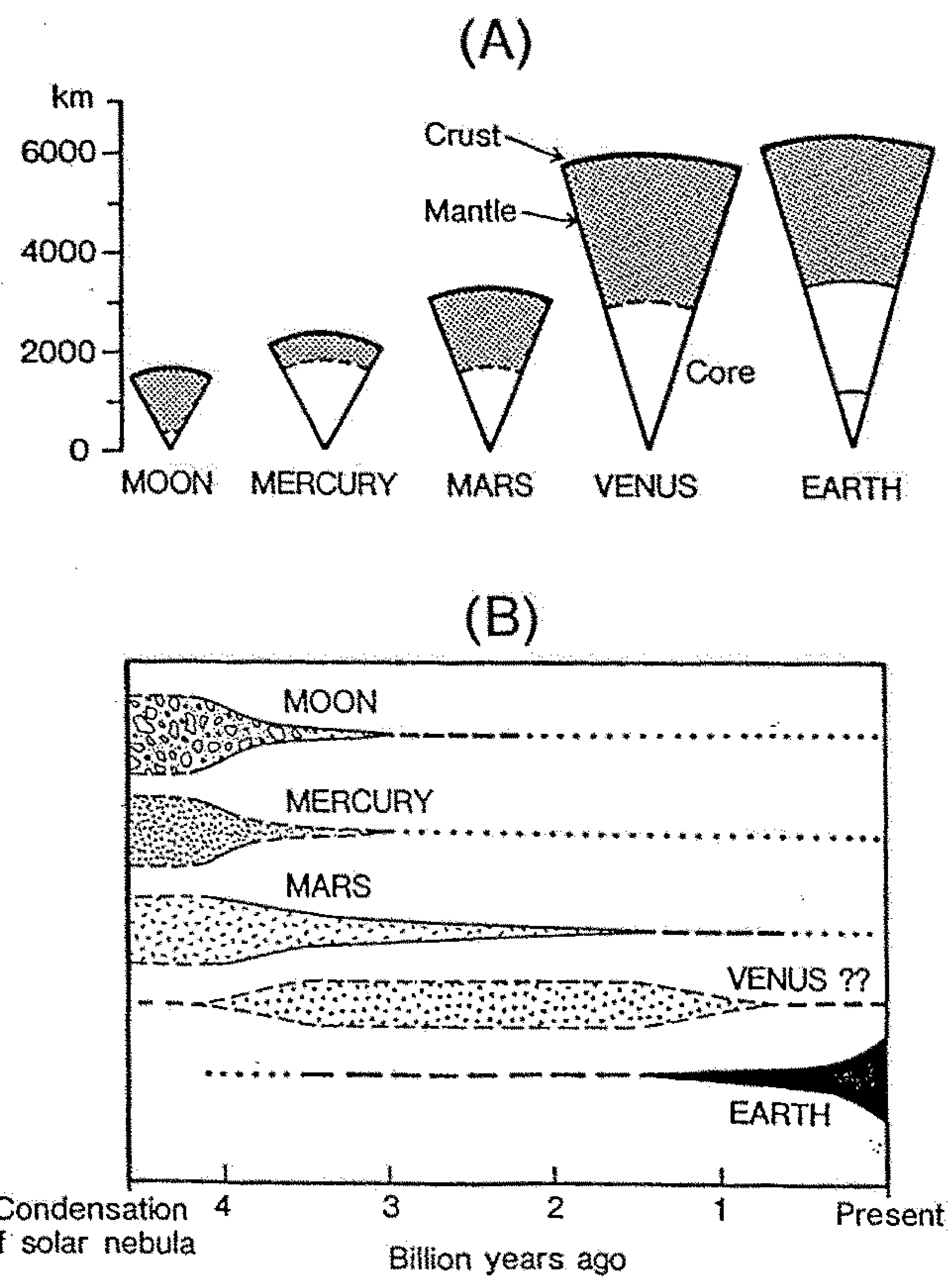


Figure 4.13. (A) Relative sizes and structures of the inner, terrestrial planets, and of the Moon (see also Table 4.1). (B) Inferred surface reworking of these bodies due to volcanism, erosion, deposition, and meteorite bombardment as a function of time. Evidently, surficial modification of most of the inner planets except the Earth (and possibly, to a lesser extent, Venus), virtually ceased 3 to 4 billion years ago. (*Source:* Adapted from J. W. Head and S. C. Solomon, *Tectonic evolution of the terrestrial planets, Science*, vol. 213, 1981.)

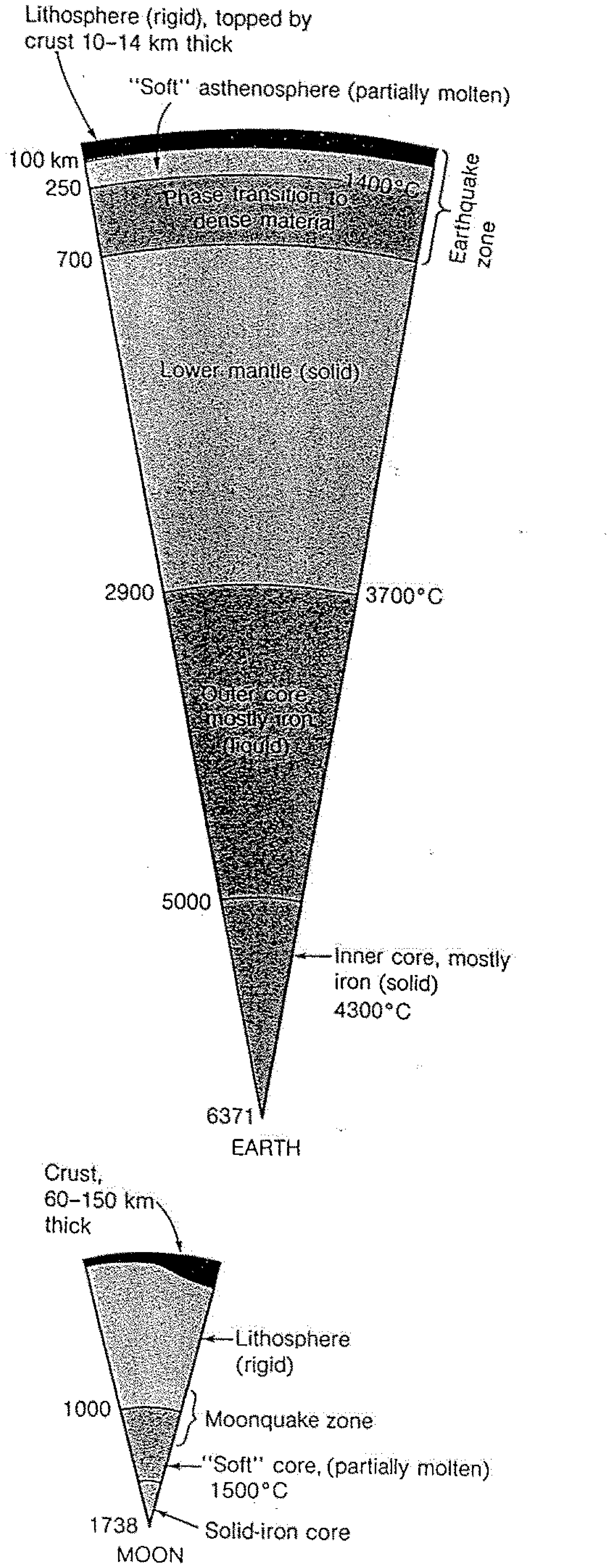
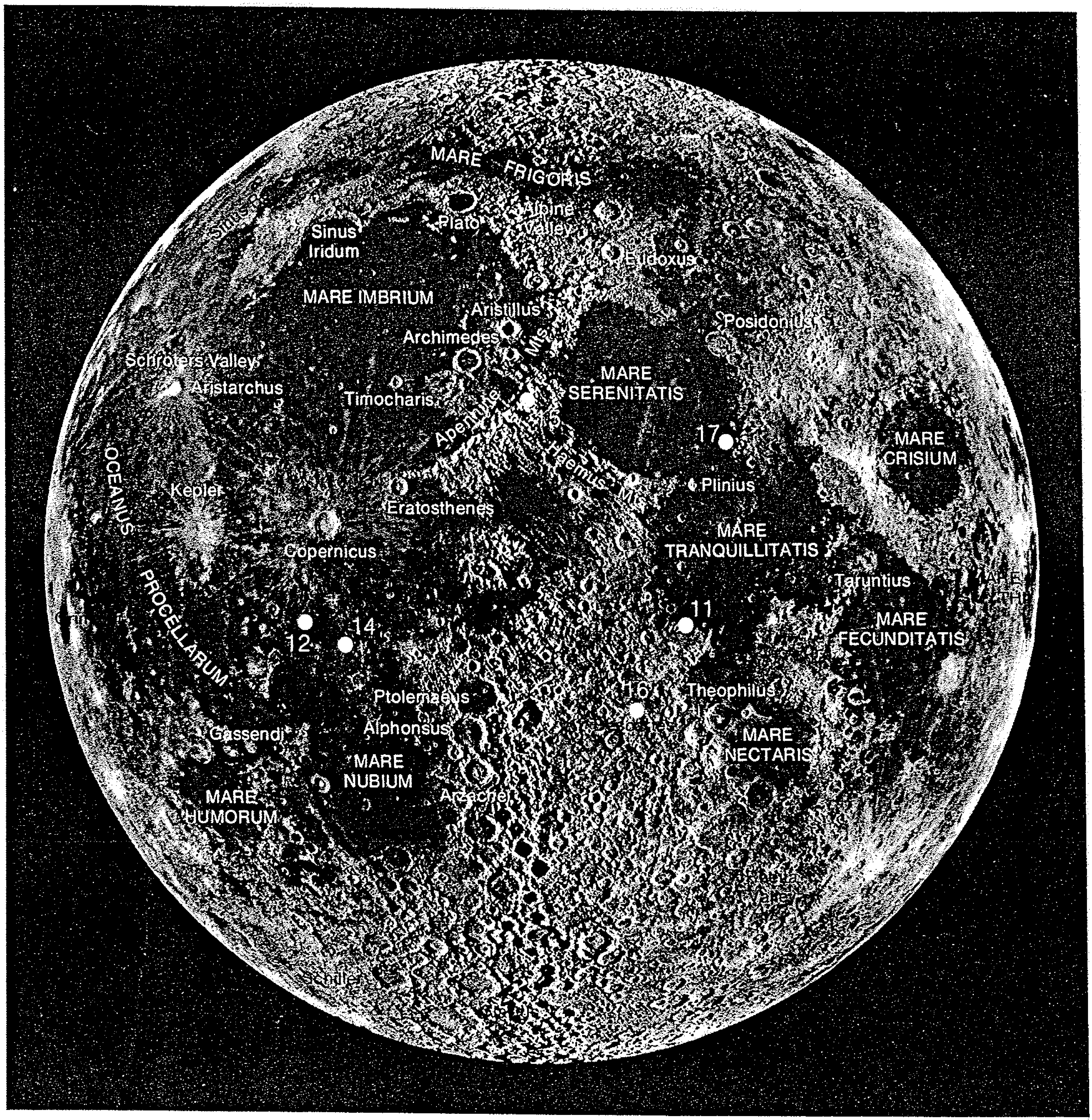


Figure 22-12

Comparison of the internal structures of Earth and Moon. Note the thick, strong, unbroken Moon lithosphere in contrast to the thin Earth lithosphere, which breaks into plates moving over the asthenosphere. Moonquakes are tiny and infrequent and occur halfway to the lunar center; earthquakes are a feature of Earth's outer layers, where plate tectonics takes place.



Lunar landing sites (white circles)

Apollo 11: Sea of Tranquility	Apollo 12: Ocean of Storms	Apollo 14: Fra Mauro
Apollo 15: Hadley-Apennine	Apollo 16: Descartes	Apollo 17: Taurus-Littrow

Figure 22-1

Photograph of lunar surface showing major features: dark maria covered by younger basaltic lava flows and light-colored highlands, whose heavy cratering testifies to their great age. White circles show the Apollo landing sites. [Lick Observatory photograph.]

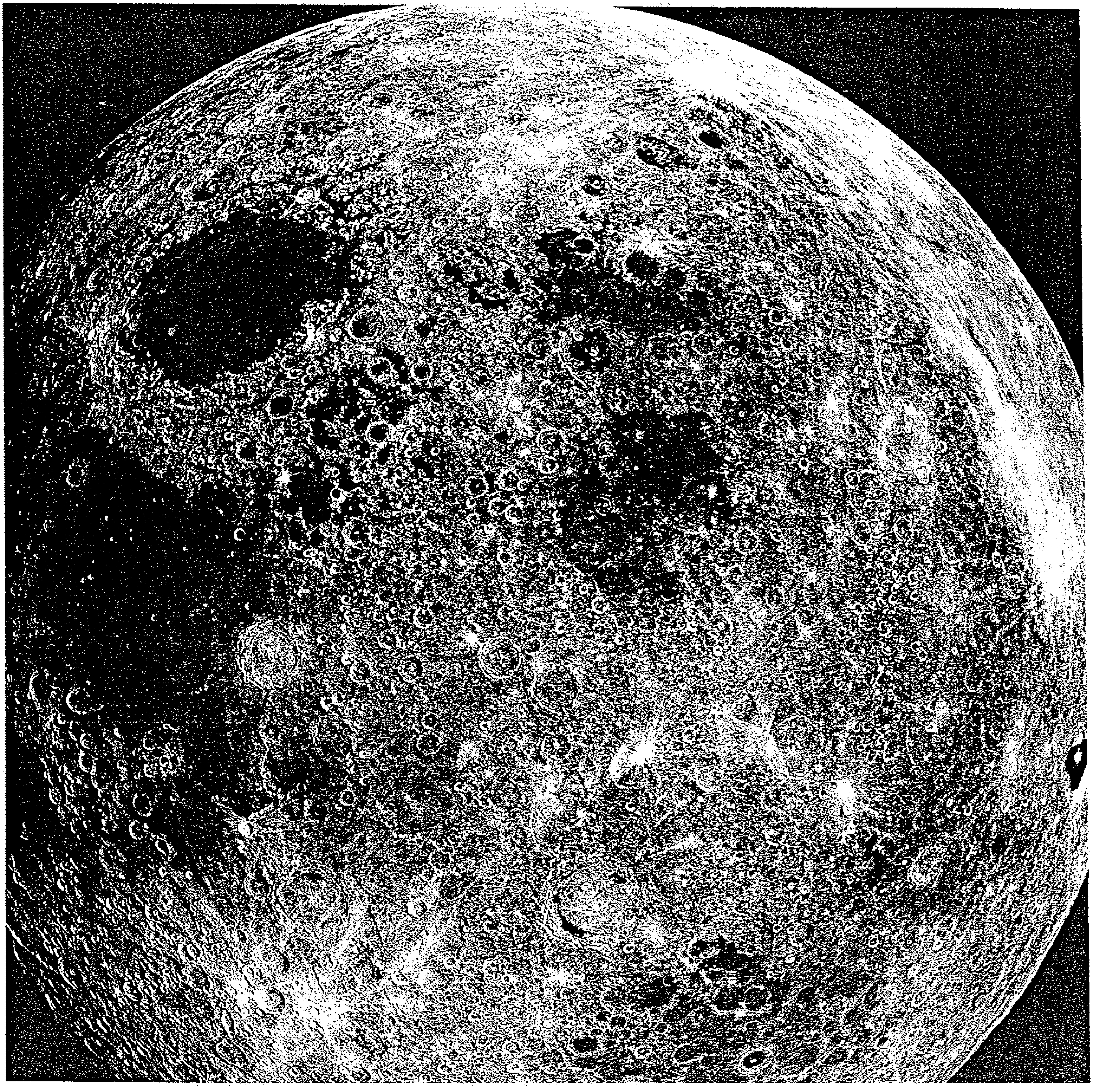
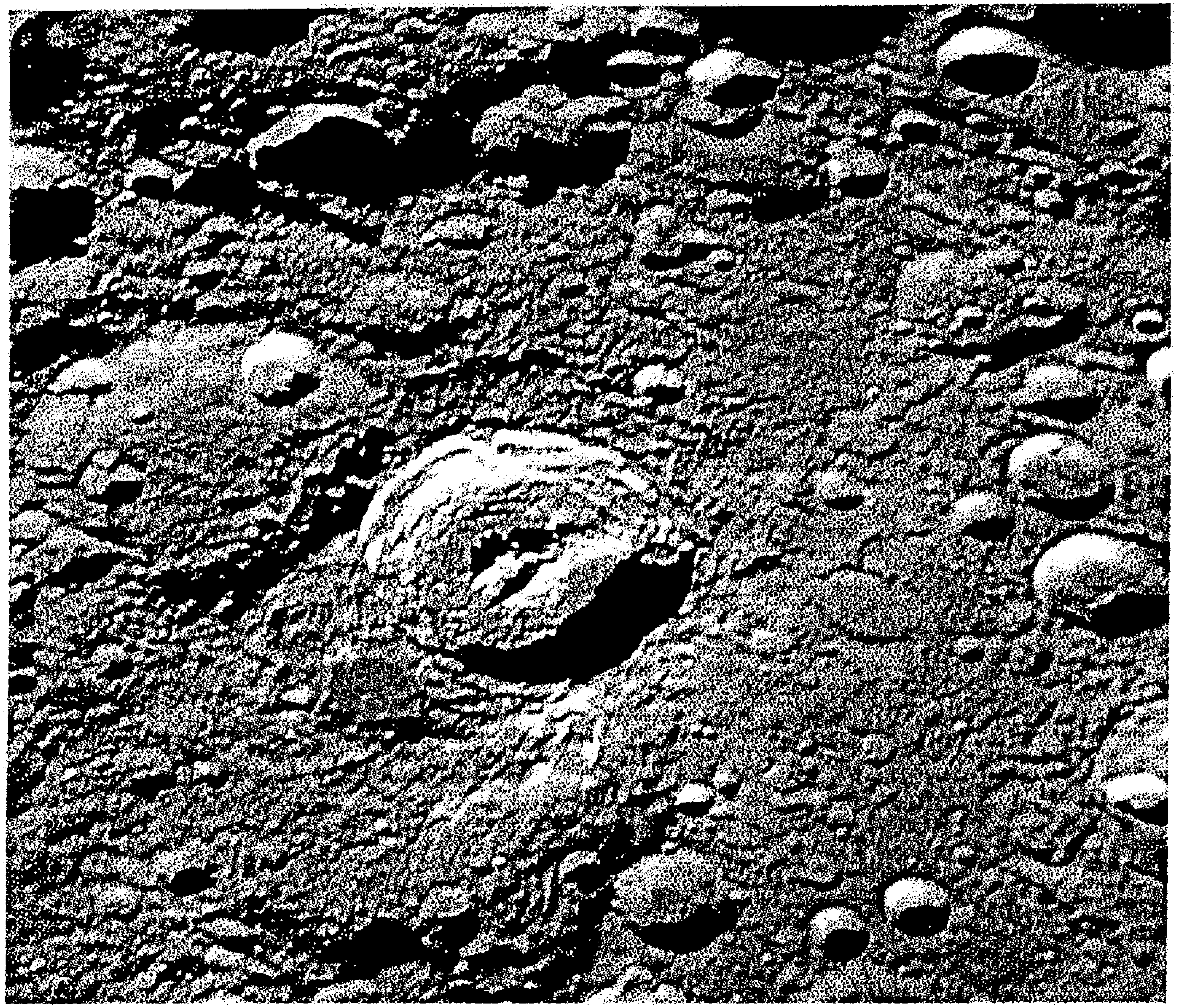


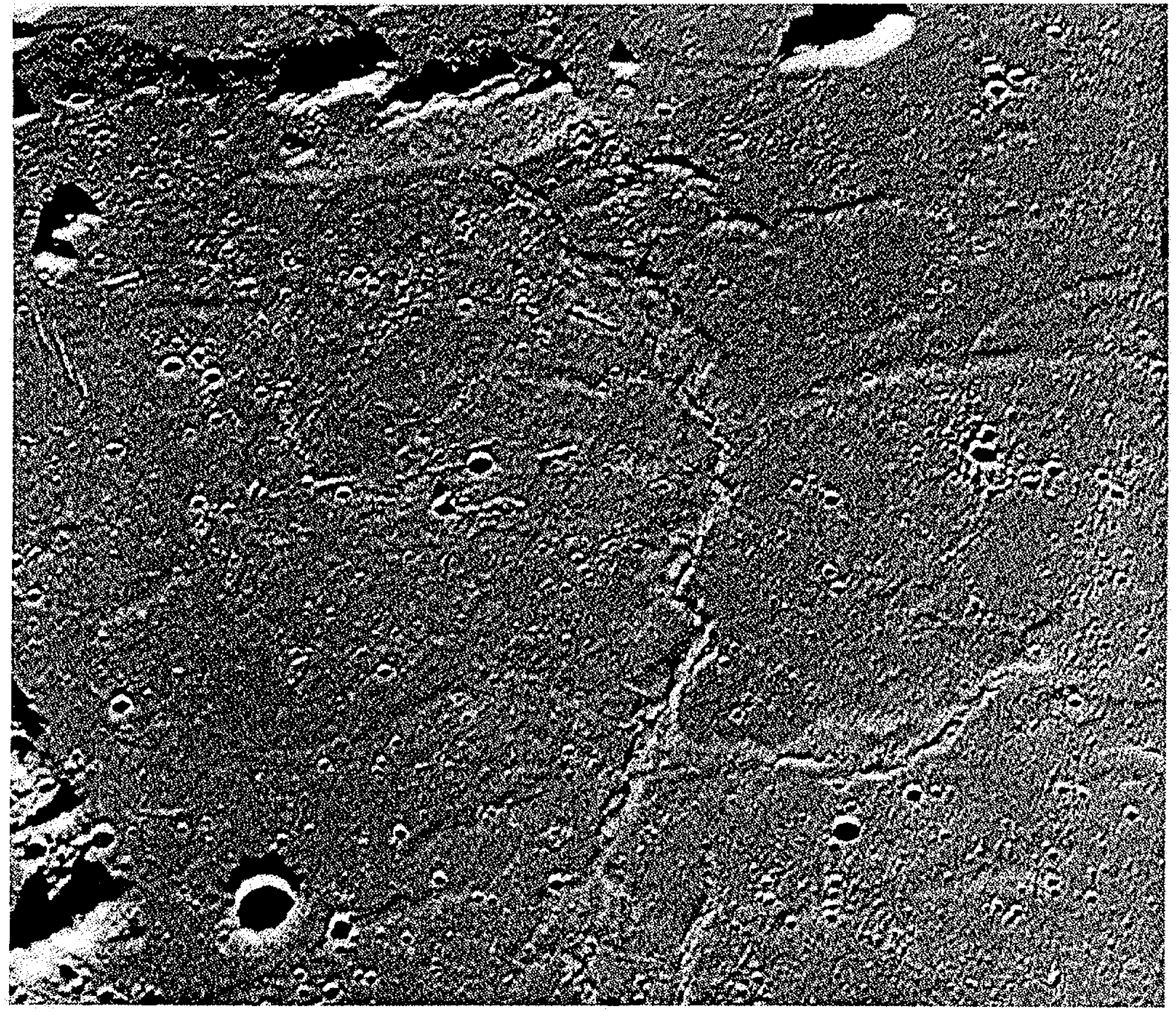
Figure 22-2

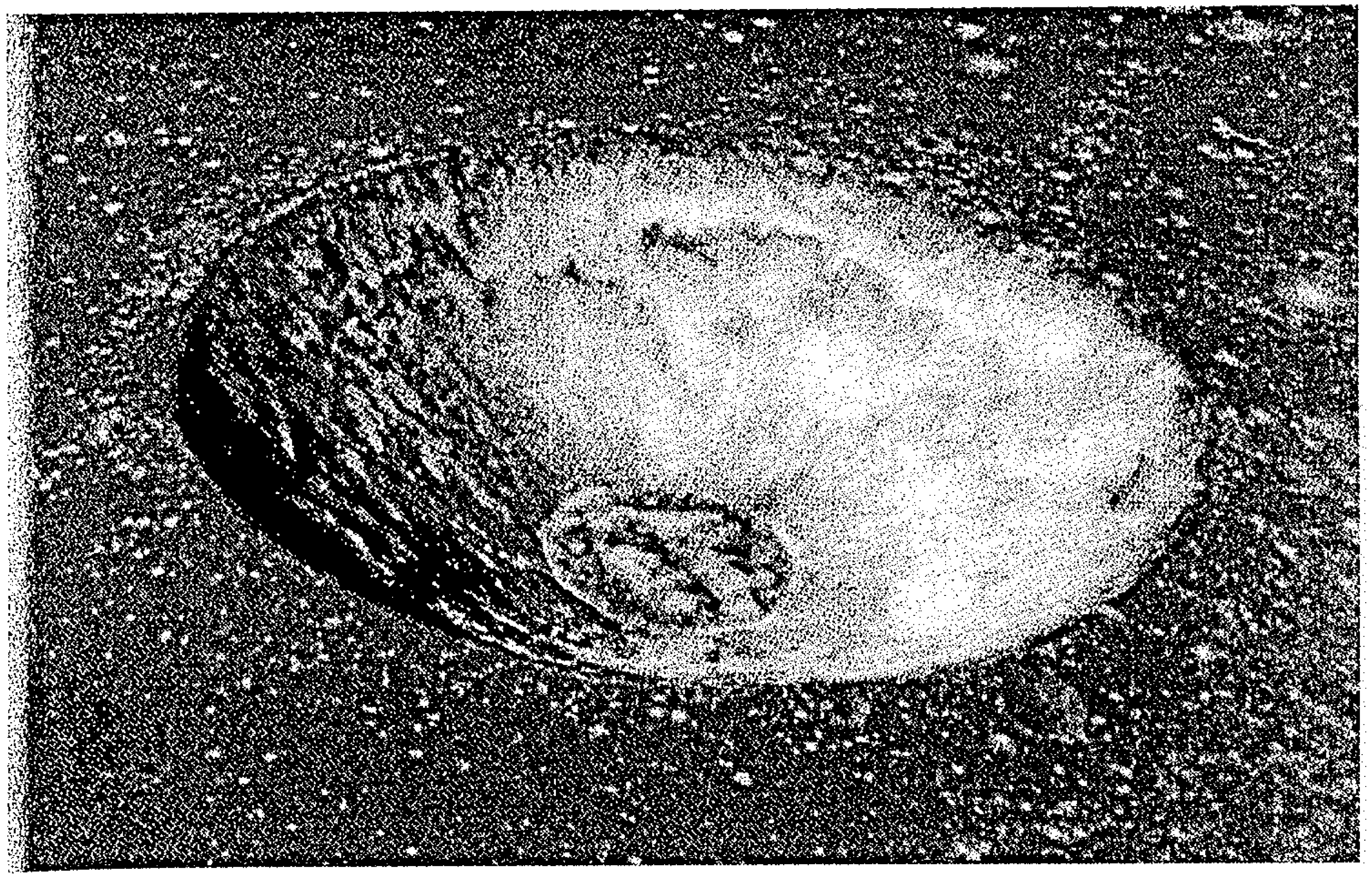
Apollo 8 view of the Moon over east limb. The right half of the photograph covers regions not visible from Earth. The bright-rayed crater at top right is Bruno. For comparison with the previous figure, note that the irregular mare in left center is Fecunditatis. Mare Crisium is above it. [From NASA.]

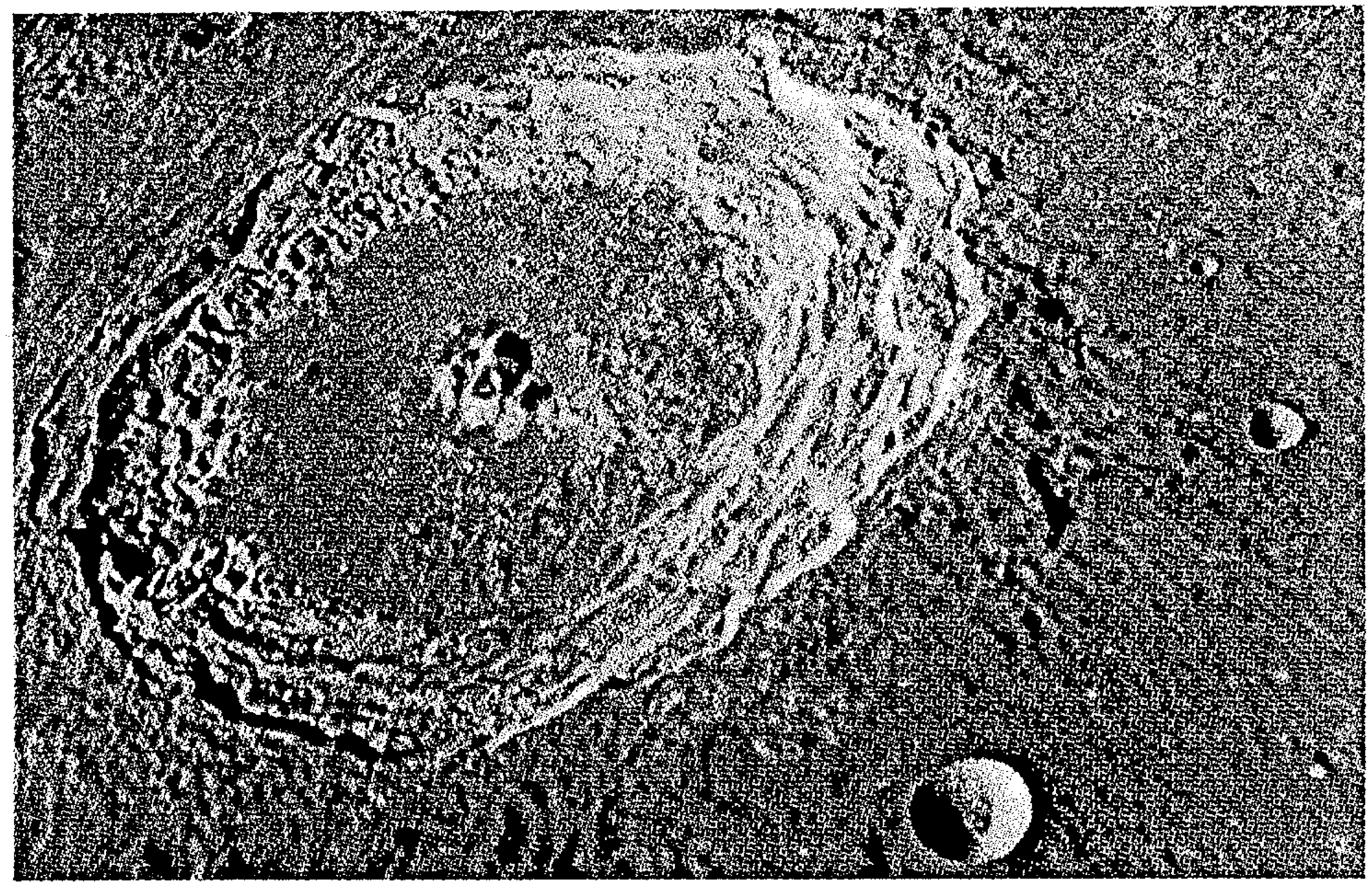
1 – ***Měsíční kontinent.*** *Kráterové pole na odvrácené straně Měsíce v okolí kráteru King (uprostřed), o průměru 76 km.*



2 – ***Měsíční moře.*** *Mořské hřbety v Zálivu středu (Sinus Medii).*





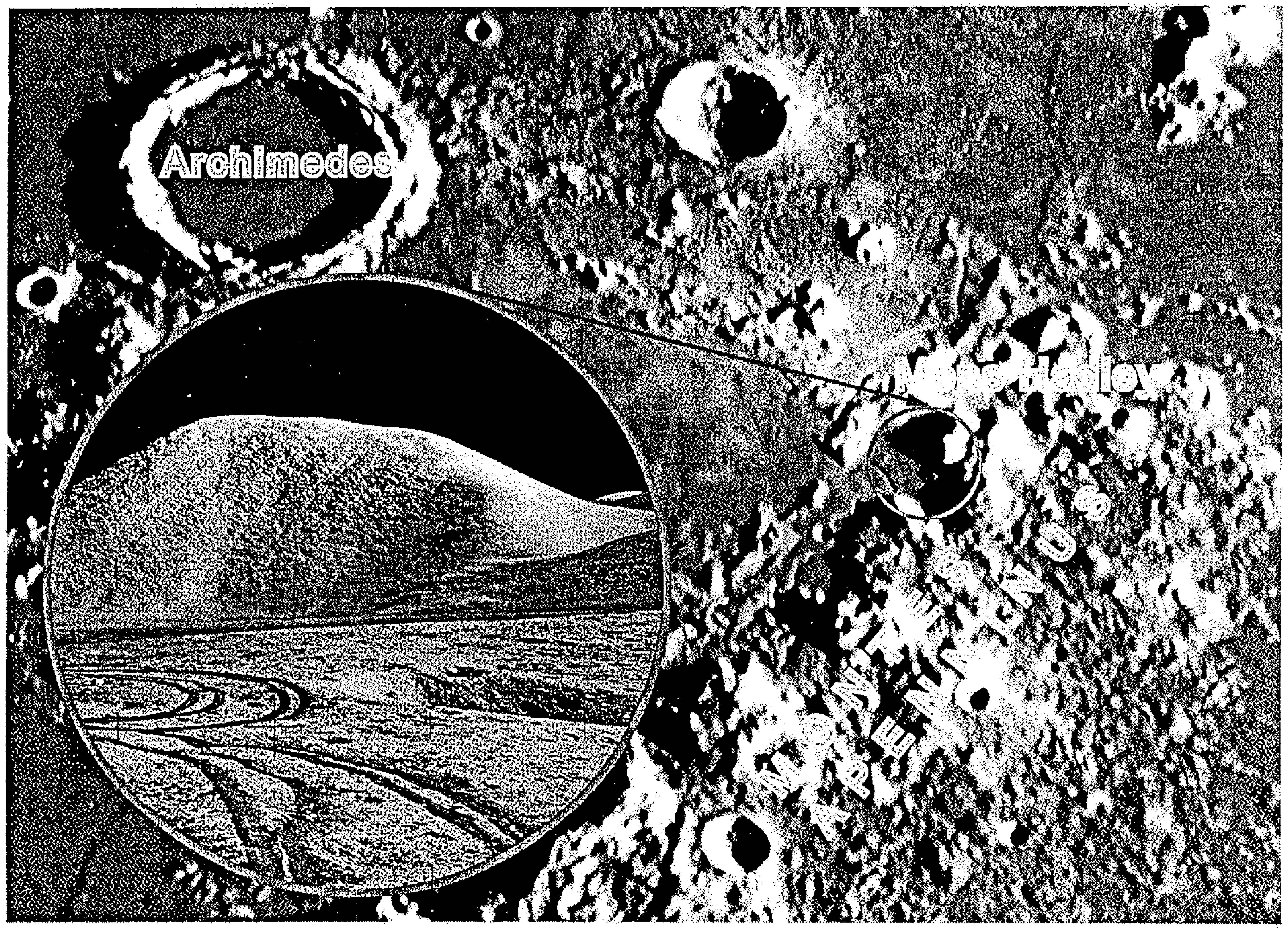


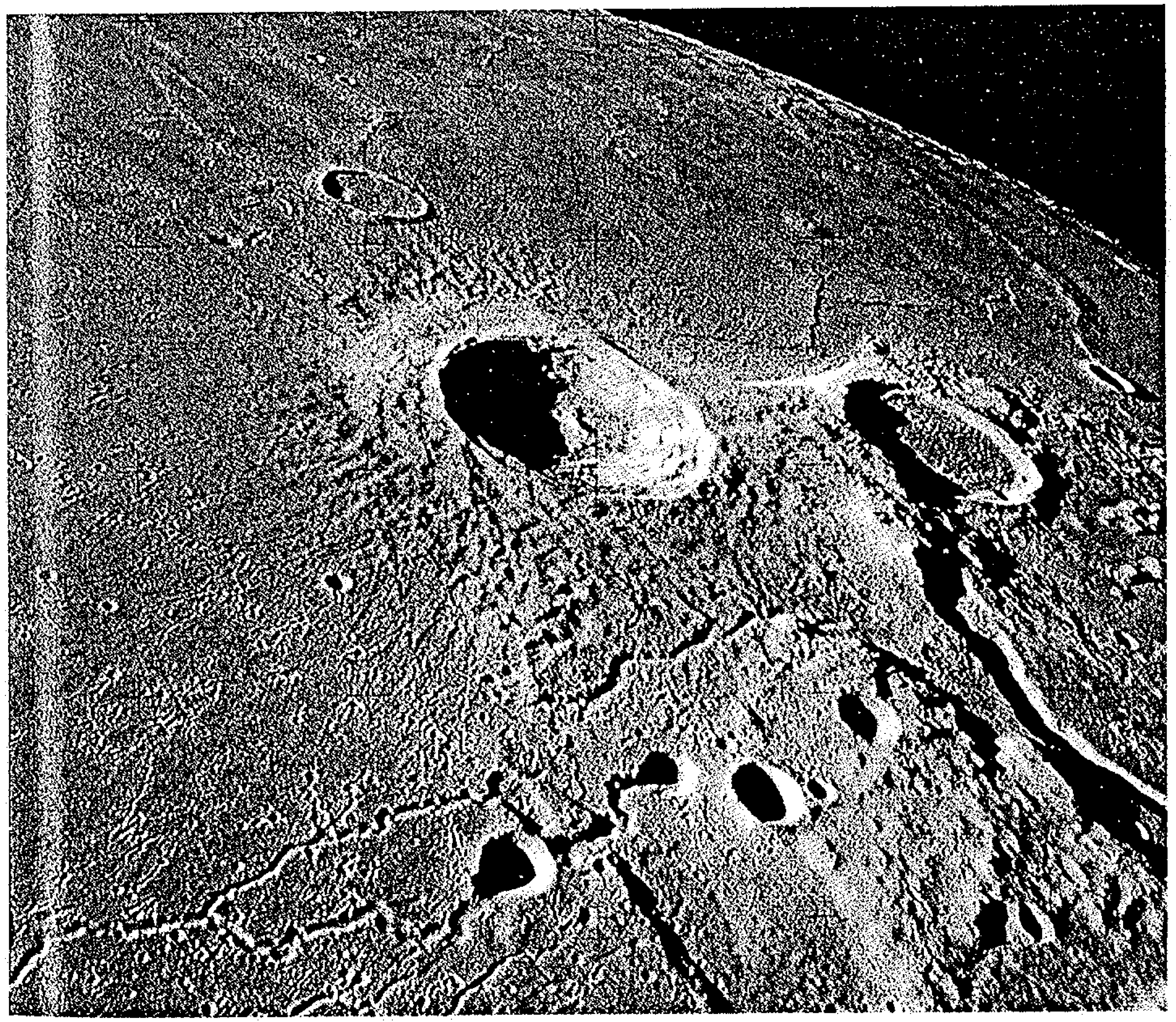
3 – ***Jednoduchý kráter*** *o průměru 8 km.*

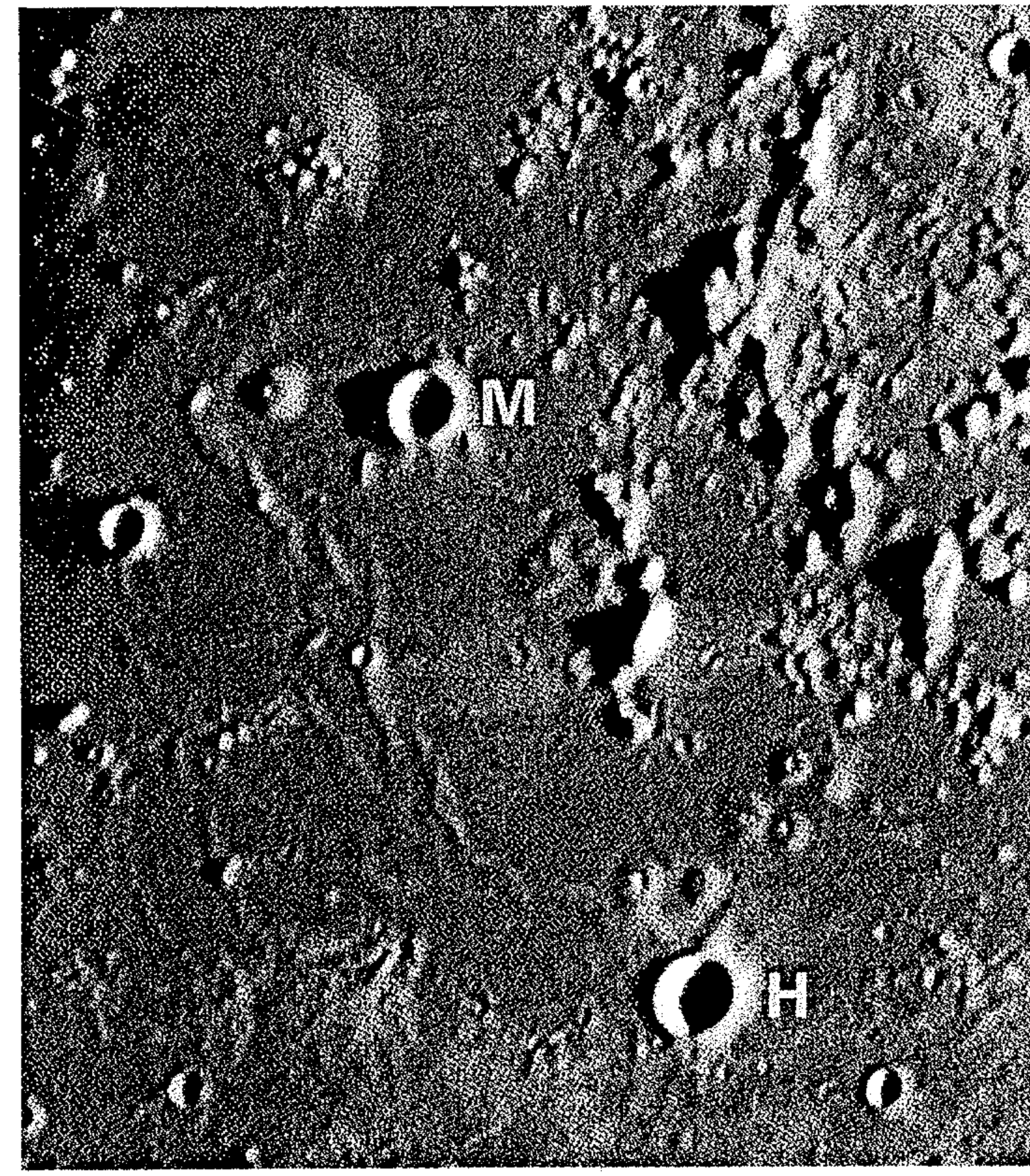
4 – ***Složitý kráter*** *(Langrenus, průměr 132 km).*

5 – ***Část měsíčních Apenin,*** *vlevo nahoře kráter Archimedes (průměr 83 km, hloubka 2500 m). Vložený snímek je z expedice Apollo 15.*

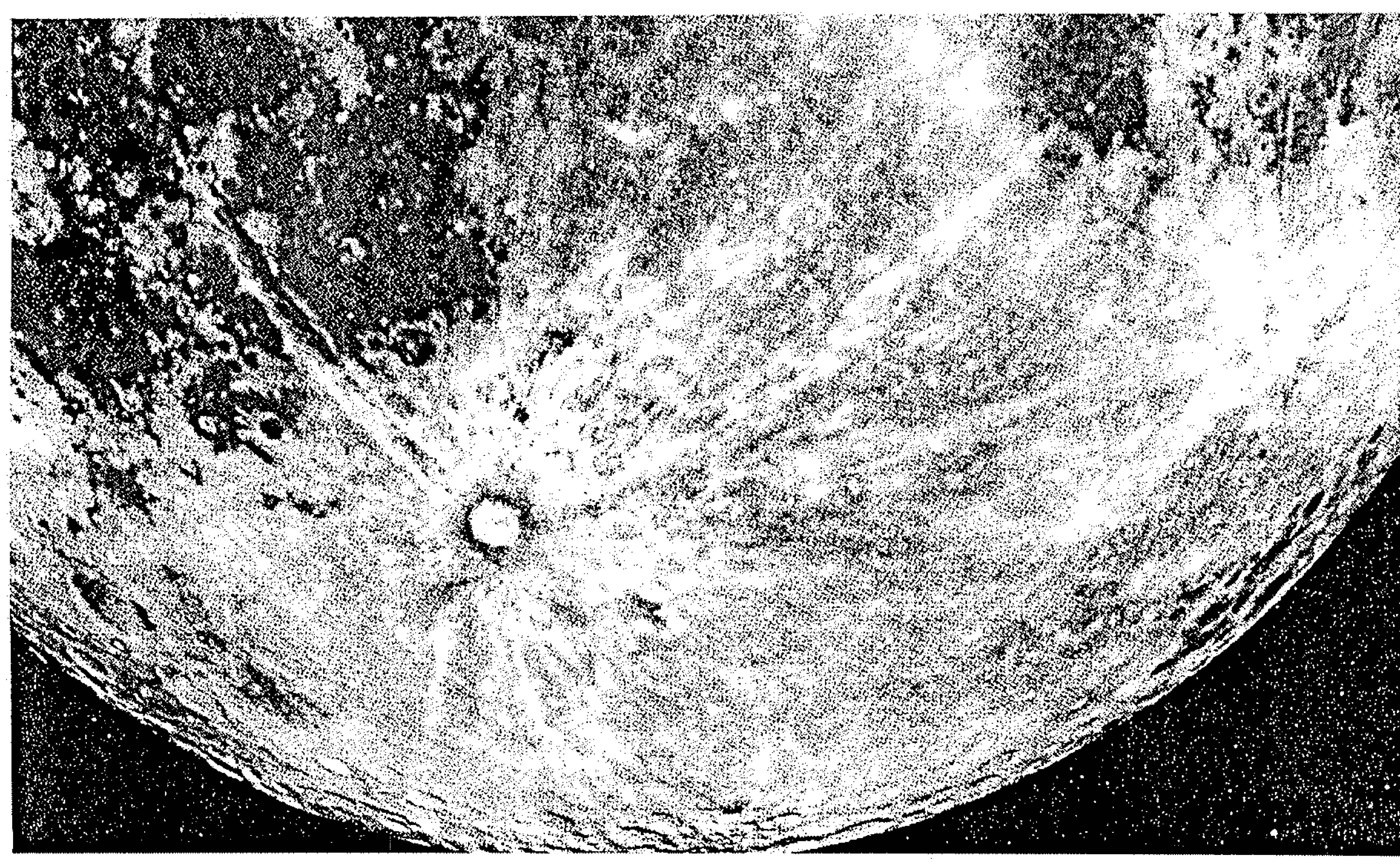
Vpravo: V kroužcích je vyznačena ***hora Mons Hadley poblíž místa přistání Apolla 15****. Vložený snímek z expedice Apollo 15 ukazuje mírné svahy, typické pro hory na Měsíci; v popředí jsou patrné stopy měsíčního elektromobilu.*







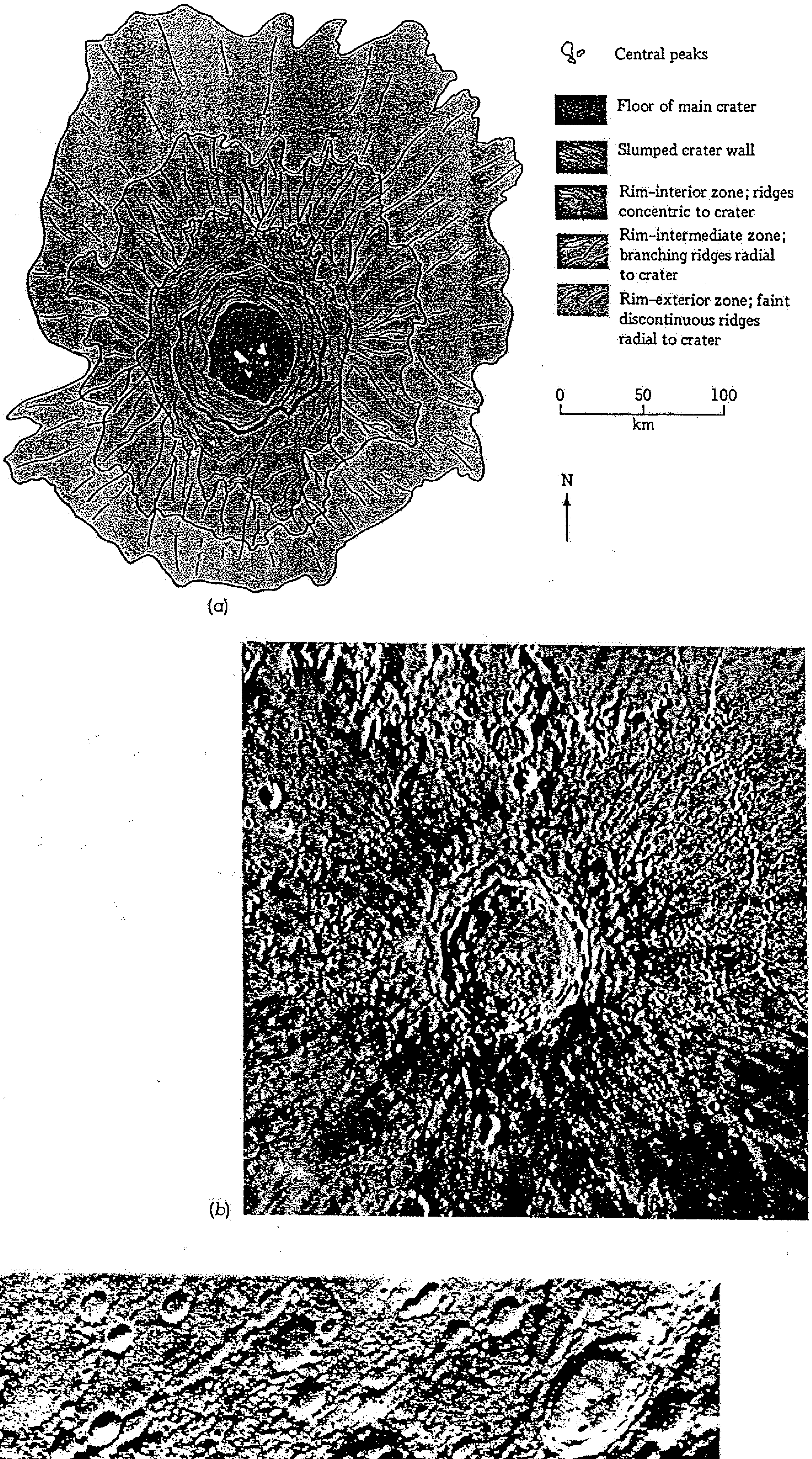
Nahoře: Od kráteru Herodotus (u pravého okraje snímku) vybíhá mohutná ***brázda, zvaná Vallis Schröteri*** *(Schröterovo údolí).*



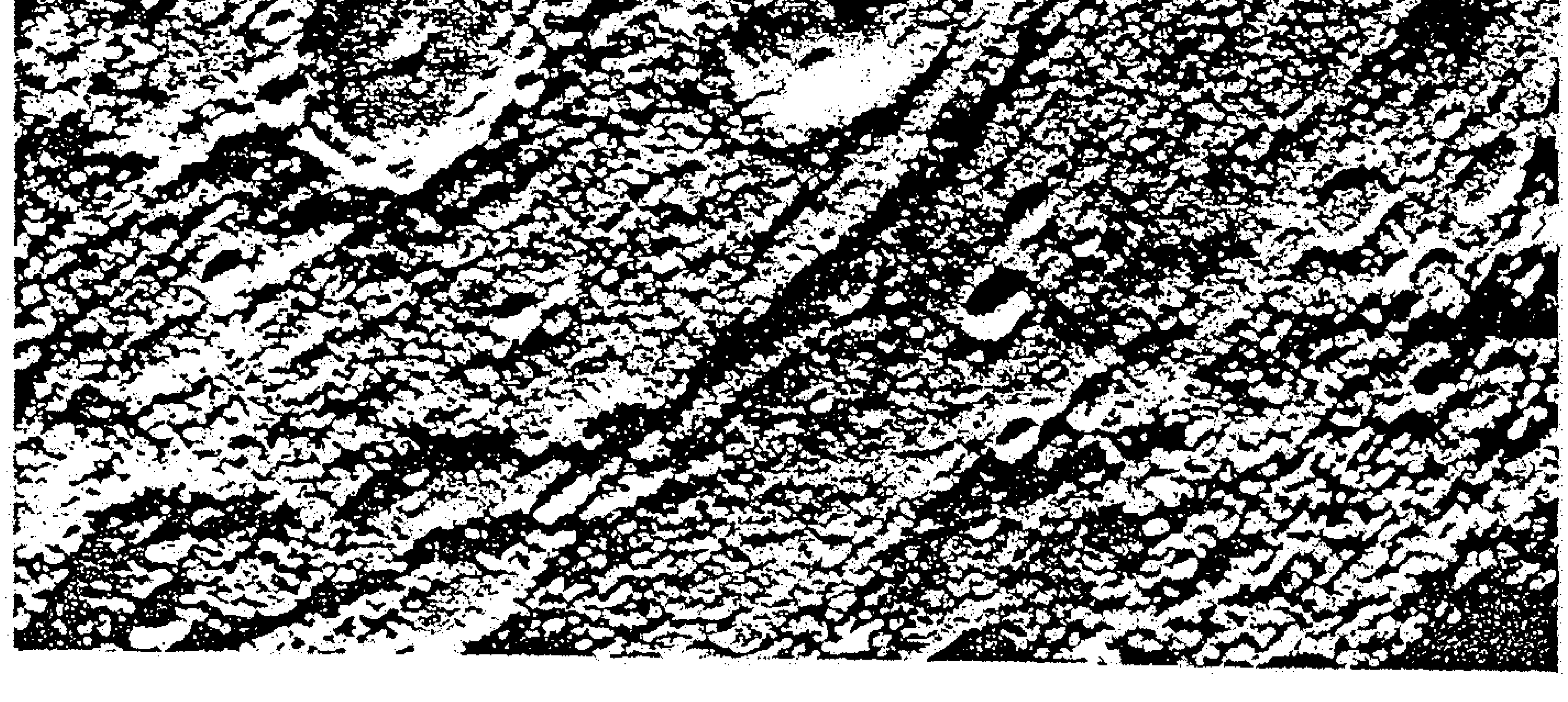
6 – ***Brázdy*** *u kráterů Aristarchus a Herodotus (mapa na str. 43).*

7 – ***Lunární dómy*** *u kráterů Hortensius (H) a Milichius (M); mapa na str. 43.*

8 – ***Kráter Tycho*** *s nejmohutnější soustavou jasných paprsků.*



20.6 (*a*) Map of Copernicus, showing the extent of the major zones of the central crater. (*b*) Telescopic view of Copernicus. The rays and smaller craters can be seen in the photograph. [Mount Wilson Observatory. Map based on H. H. Schmitt et al., "Geologic Map of the Copernicus Quadrangle of the Moon," *U.S. Geol. Surv. Atlas of the Moon*, map I-515, LAC-58, 1967.]



20.2 The cratered surface of Mercury is similar to that of our Moon and to some of the moons of Jupiter and Saturn. This detail of a portion of the planet also shows a cliff extending for over 300 km from lower left to upper right. [NASA, *Mariner 10*.]

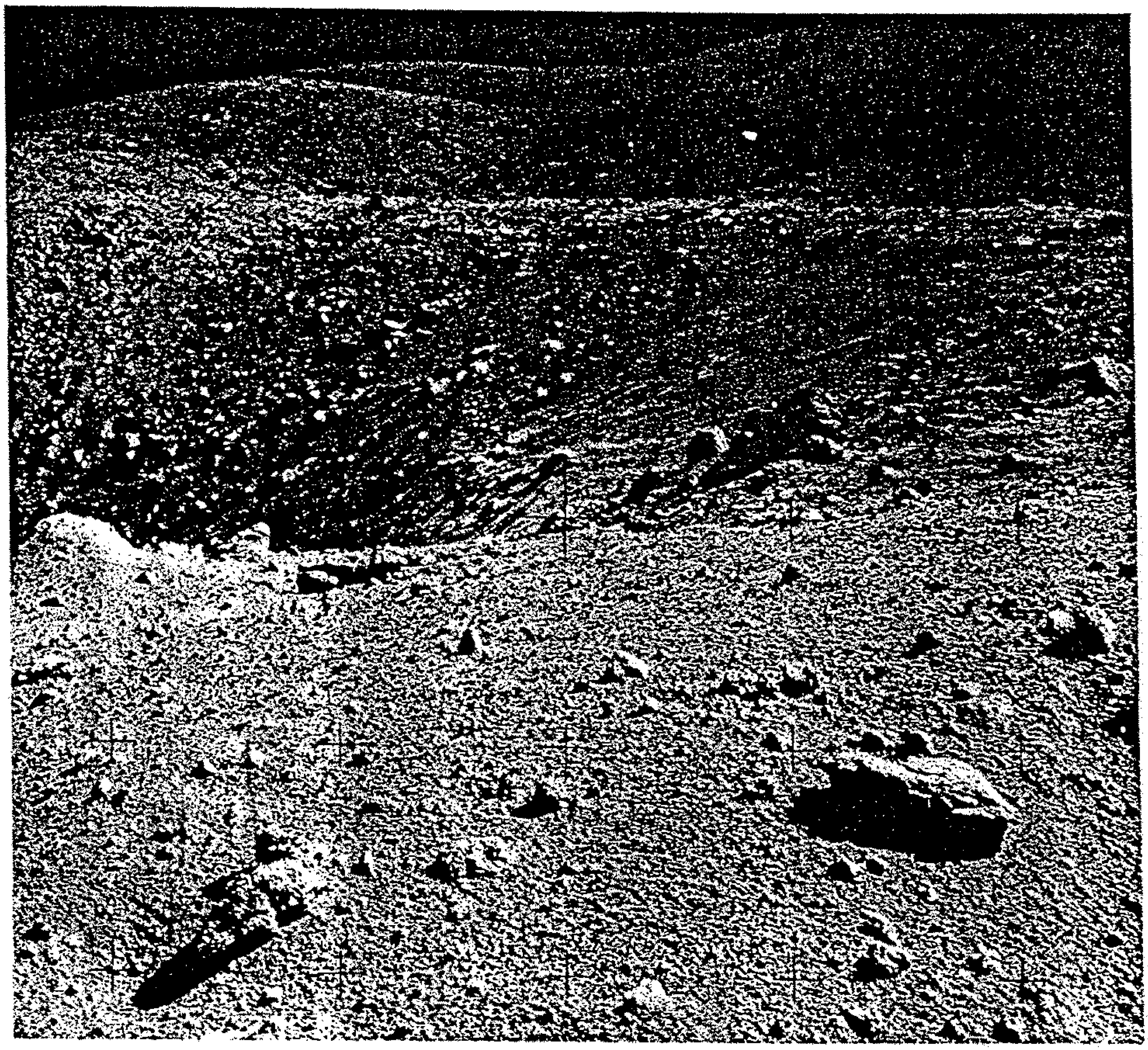


Figure 22-4

Apollo 16 mission to Descartes. This photograph was taken from the rim of a crater about 1 km in diameter and 230 m deep. The rim, 50 m high, is a flap of lunar formations blown out and overturned by the impact explosion. A meteorite about the size of a football field would have produced a crater this big. The rocks in the foreground are breccias. The undulating surface in the distance is the cratered, finegrained lunar "soil," or regolith, with widely scattered pebbles and cobbles. [From U.S. Geological Survey and NASA.]

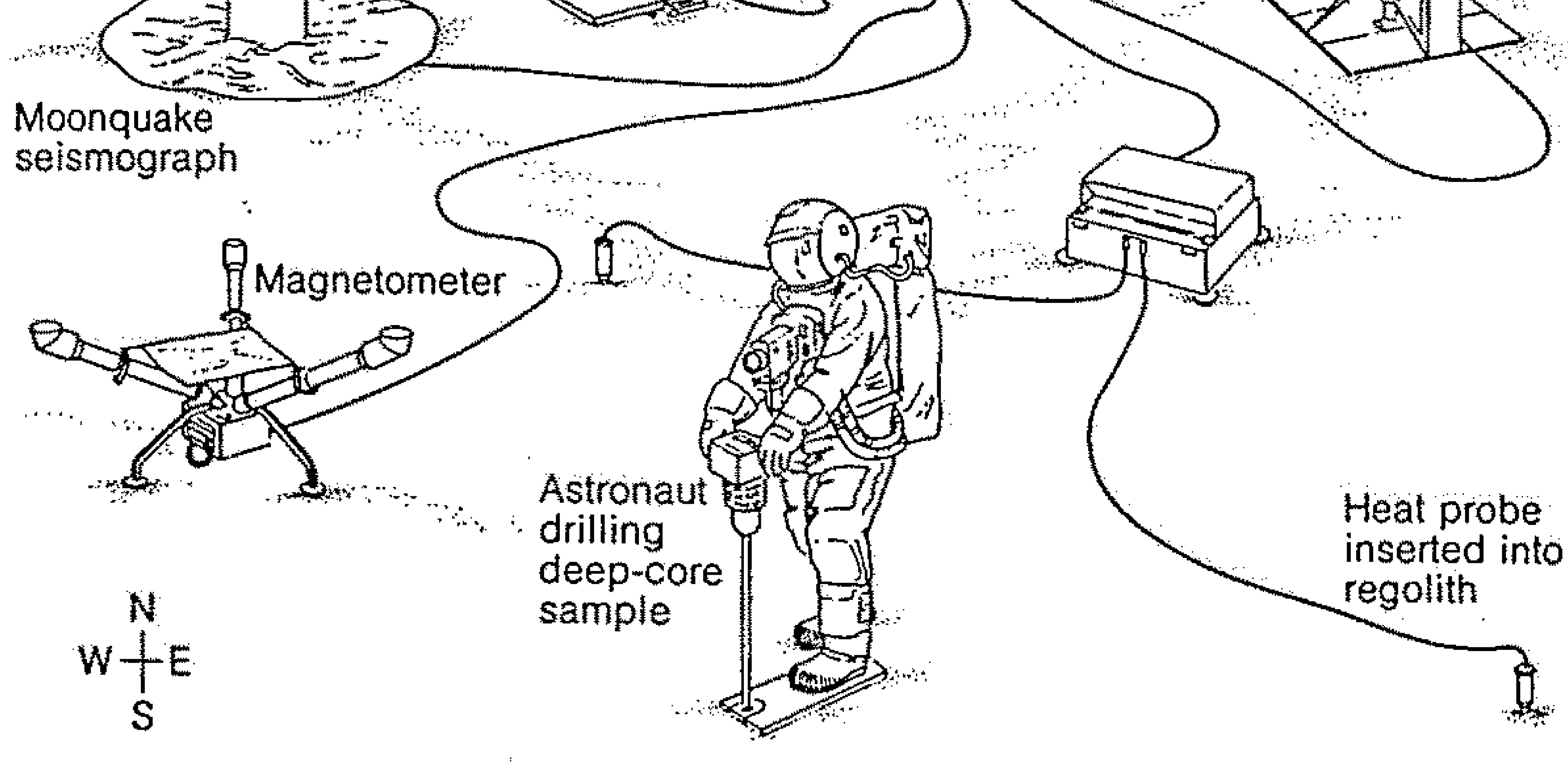
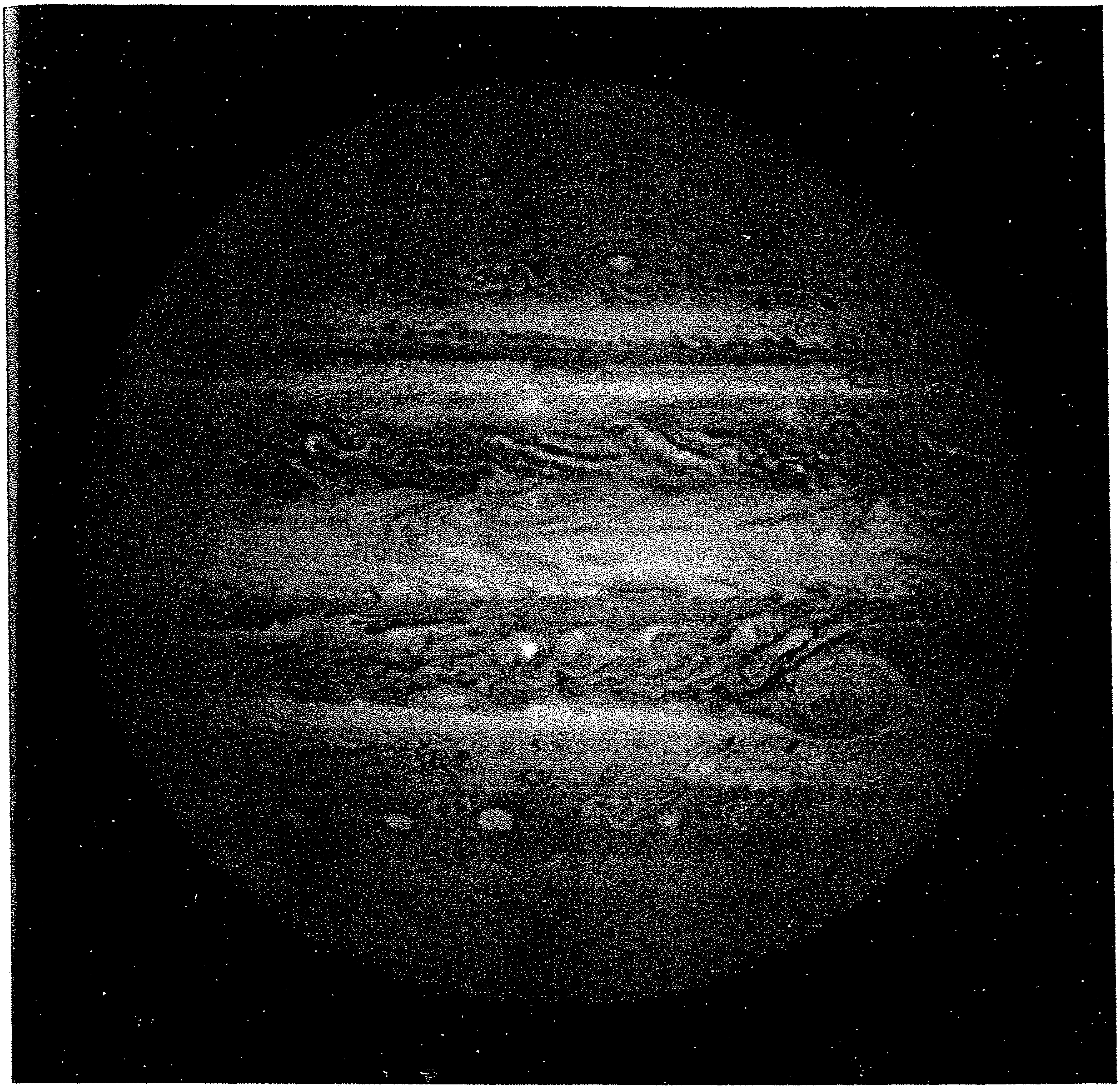
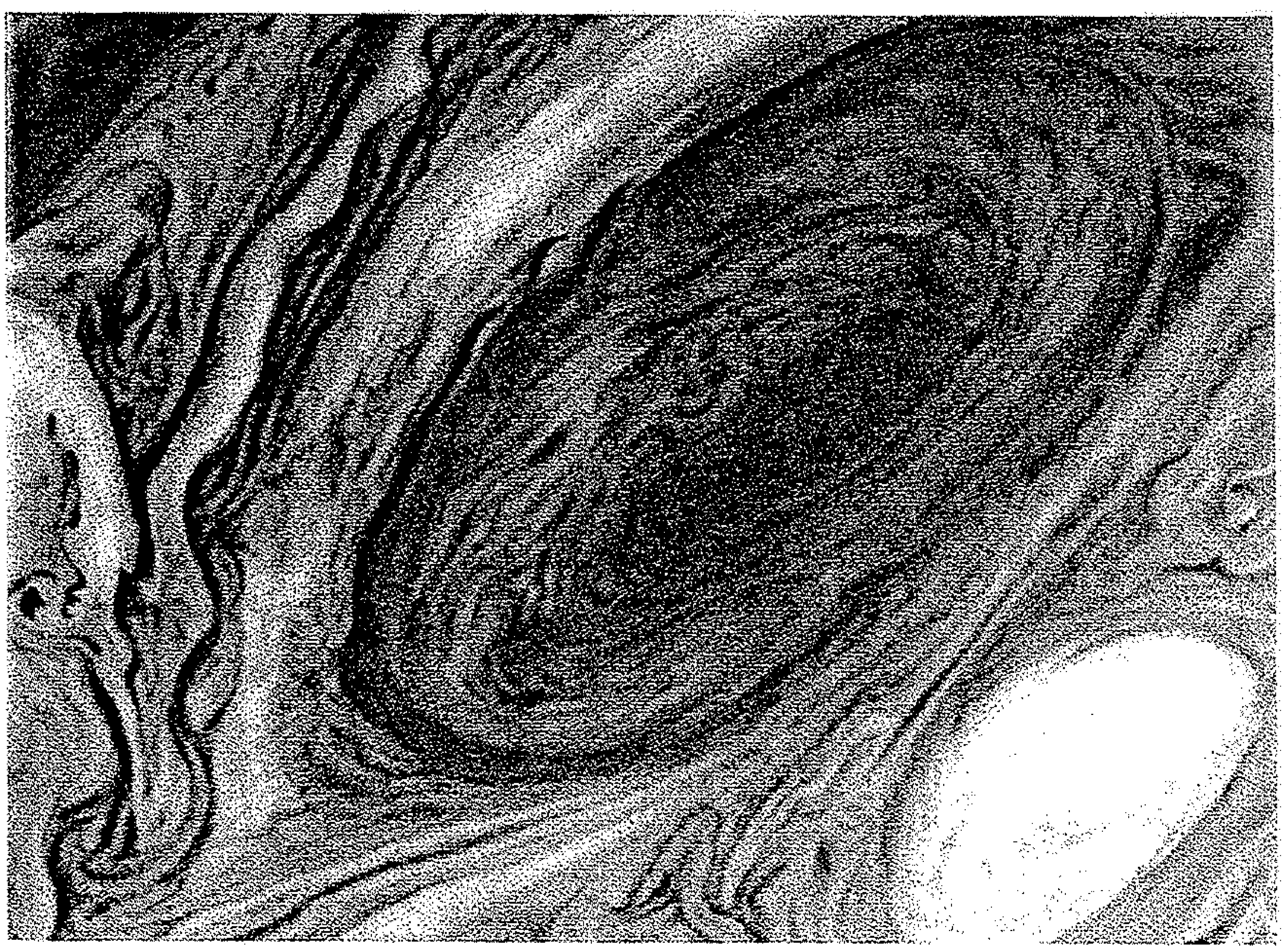


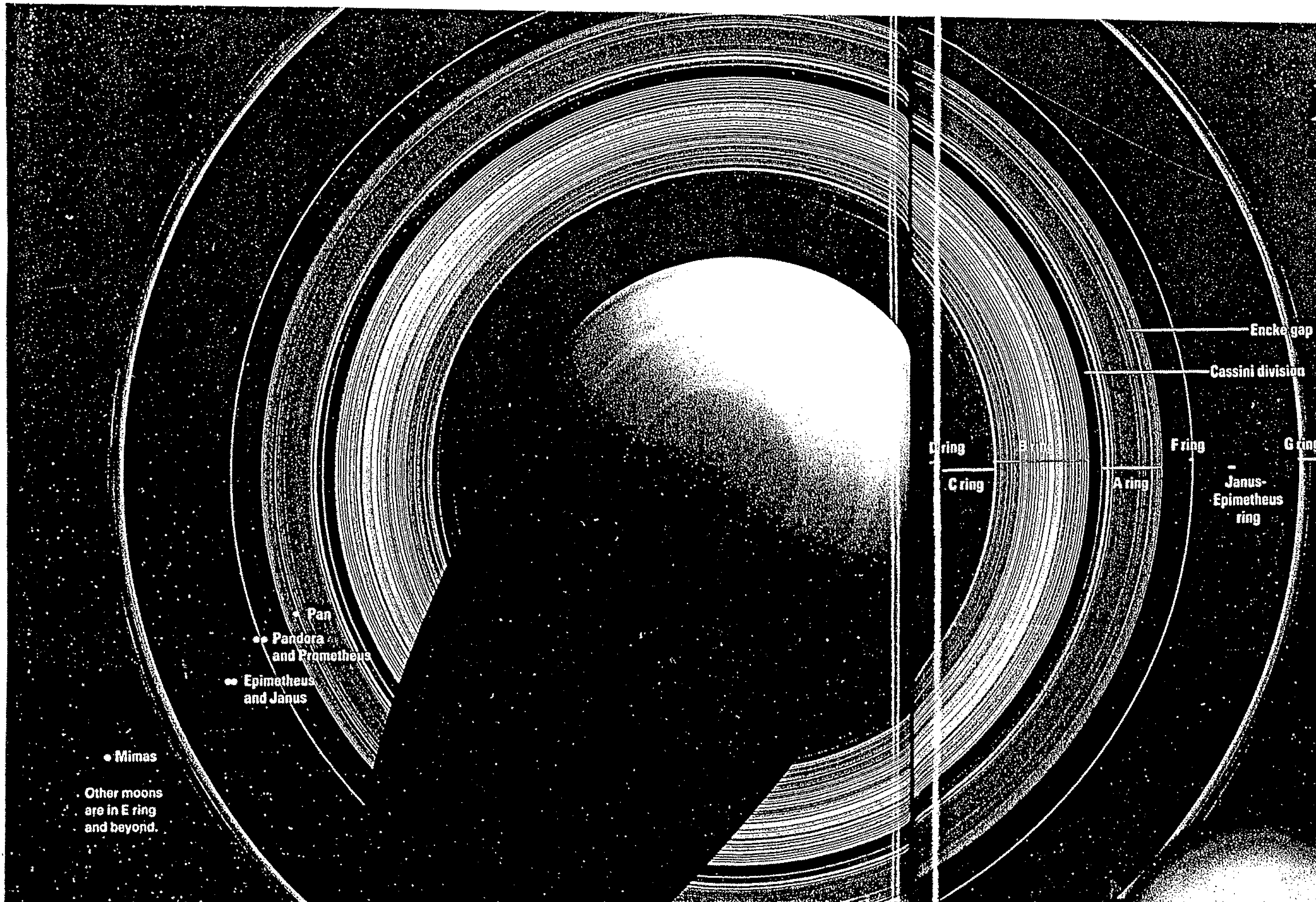
Figure 22-3

Alsep, the automatic observatory left behind on the surface of the Moon by the Apollo astronauts. Data from seismographs, magnetometers, heat-flow probes, and gas detectors were transmitted back to Earth for many years. In the active seismic experiment, a mortar fires an explosive charge on signal from Earth to generate seismic waves in the lunar crust, which are picked up by the geophones. [From NASA.]





Vlevo: ***Velká rudá skvrna je nejstálejší známý atmosférický útvar na Jupiteru,*** *pozoruje se přes 120 let (podle některých historiků přes 300 let). Má oválný tvar o rozměrech asi 12 000 krát 25 000 km a pozorování její rotace ukazují, že má povahu anticyklony, tj. oblasti vysokého tlaku. Oblačné hmoty proudí kolem jejího středu proti směru hodinových ručiček a na obvodu skvrny dosahují rychlosti přes 400 km/hod. Povrch mračen Velké rudé skvrny je výrazně chladnější a leží výše než okolní oblasti. Podobný charakter mají tzv.* ***bílé ovály*** *(jeden z nich je na obrázku vpravo dole), jejichž životnost bývá několik desítek let.*

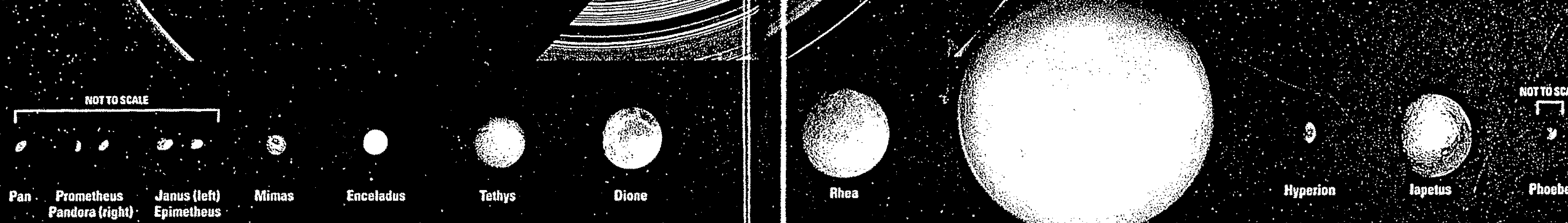


MORE THAN A PLANET

Seen from above its north pole in an artist's impression, Saturn resembles a miniature solar system, with rings spanning 165,000 miles (out to the A ring) and 56 known moons out to more than 10 million miles from the planet. A sampling of moons is shown below in the order of their distance.

Saturn is the sixth planet from the sun, 890 million miles out, and the second biggest, after Jupiter. Beneath its deep atmosphere is a layer of metallic hydrogen, wrapping a core of rock and ice. Its clouds look deceptively serene, masking thousand-mile-an-hour winds.

The rings, designated alphabetically in the order of their discovery, offer clues to how planets form in the disks of debris around young stars. The major rings contain thousands of smaller rings, some harboring small moonlets that help keep the ring particles from dispersing. Other moons help maintain gaps in the rings; the gravity of Mimas, for example, keeps particles from straying out of the B ring and into the Cassini division, which French astronomer Jean-Dominique Cassini discovered in 1675. The spacecraft that bears his name has found a multitude of new moonlets along with a new ring, between the F and G rings.



MOONS ON PARADE

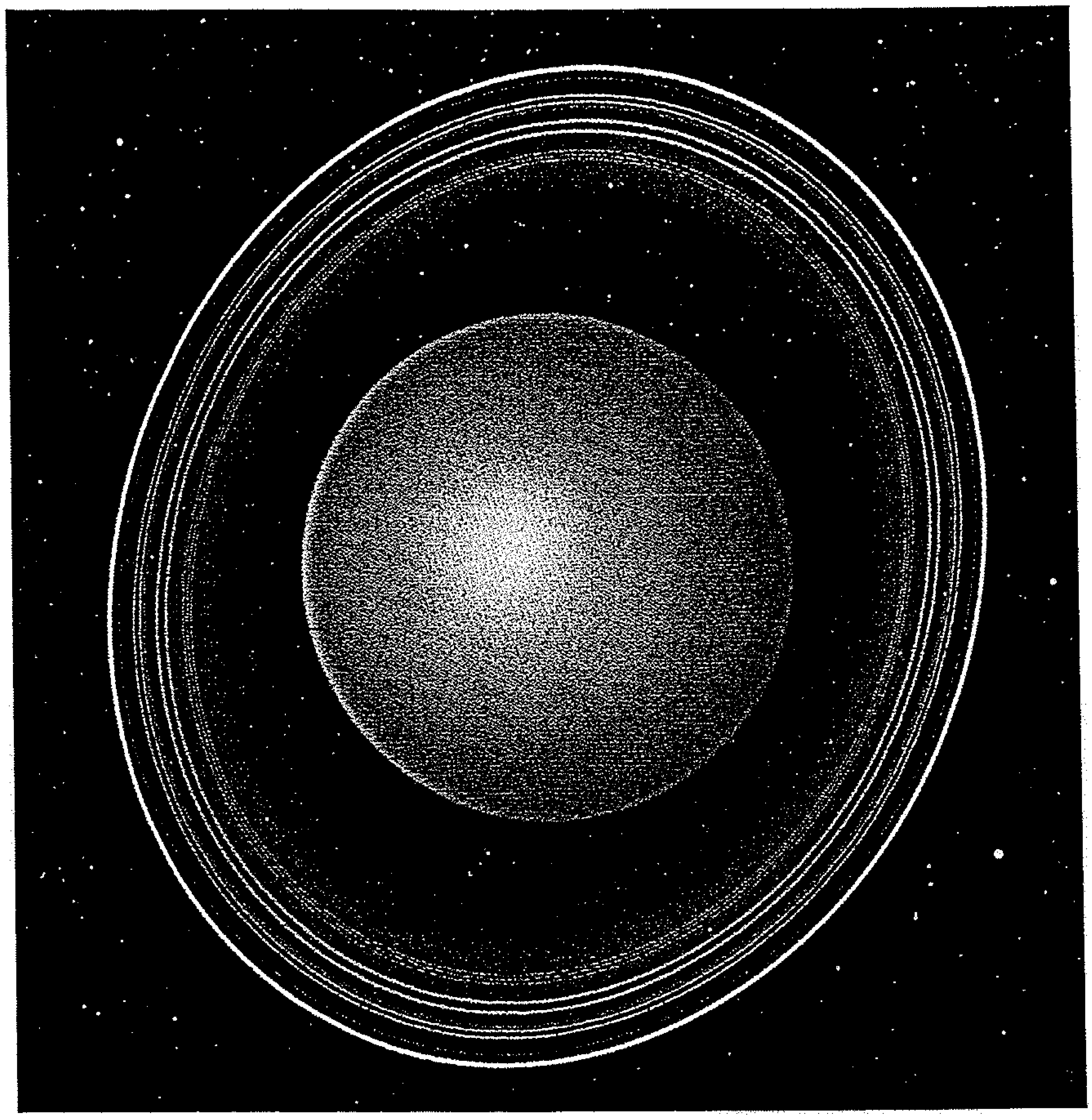
Saturn's 35 named moons range from objects a few miles across to giant Titan, larger than Mercury. Icy bodies with rock, methane, ammonia, and carbon dioxide, some of the moons may have formed when Saturn did. Others may be fragments of larger bodies, perhaps torn apart by collisions. And some, like Phoebe, may be interlopers captured from elsewhere in the early solar system.

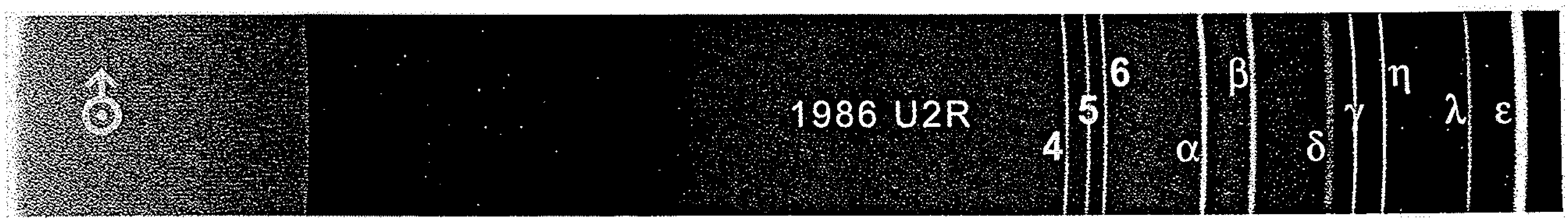
Pan, the innermost known moon, created the Encke gap by clearing debris. Prometheus and Pandora, small, cratered lumps of ice and rock, roil the fast-changing F ring. Janus and Epimetheus shed dust that fills a wispy, newly discovered ring. Ice-covered Enceladus, 310 miles in diameter, erupts plumes of water vapor and ice particles that smooth its surface and replenish the E ring. Their source may be subsurface pools of water. Tethys, Dione, and Rhea have thick coatings of heavily cratered water ice. Titan has a dense atmosphere, weather, erosion, and pools of liquid methane —an otherworldly echo of Earth. Irregularly shaped and battered, Hyperion may be the surviving remnant of a larger moon. Iapetus, perhaps the strangest moon, has one bright hemisphere and another that is a dull black.

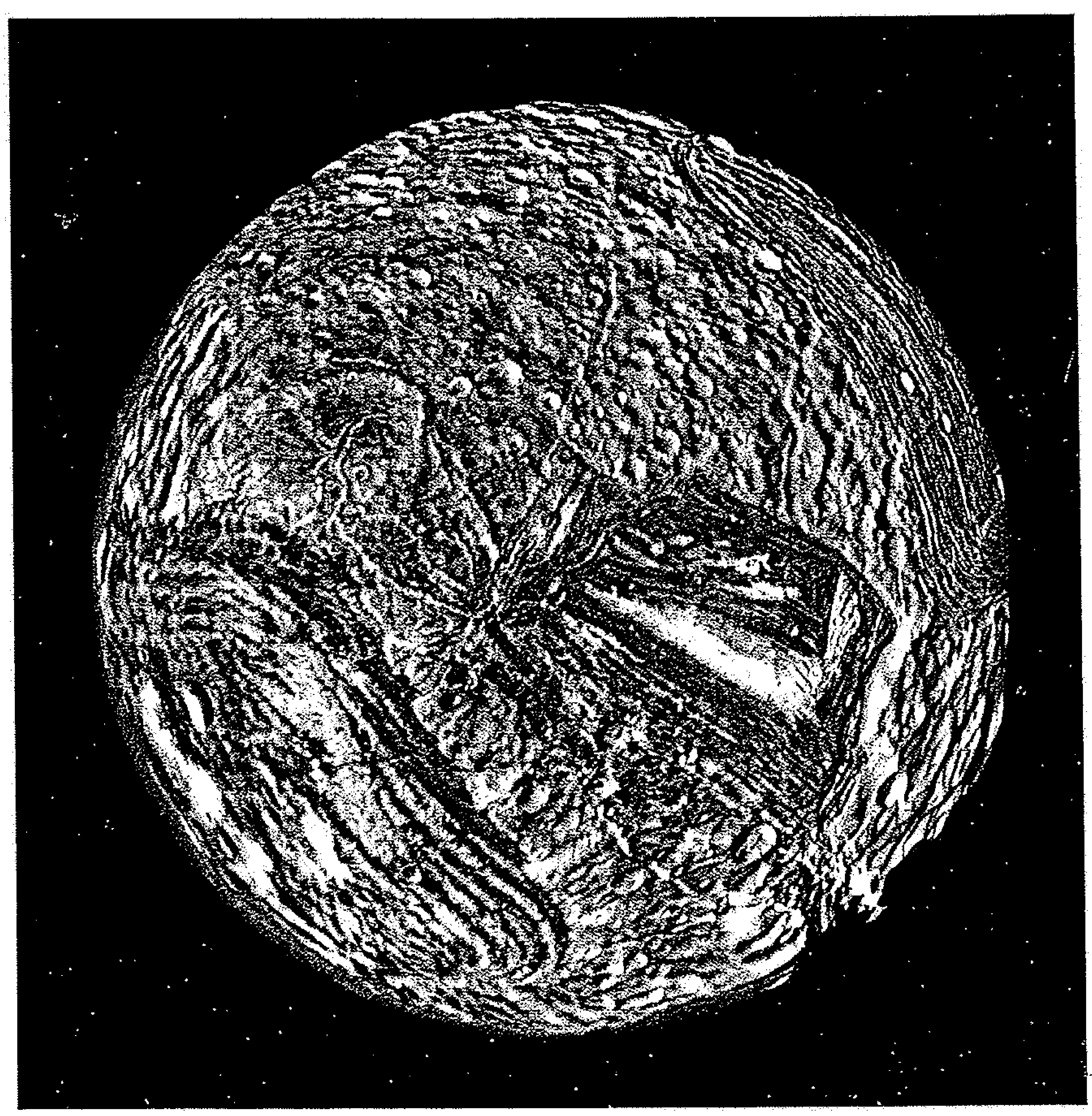
ART BY DANA BERRY, SKYWORKS DIGITAL, BASED ON NASA IMAGES. CONSULTANTS: JOSEPH BURNS, CORNELL UNIVERSITY; JEFF CUZZI, NASA AMES; RALPH LORENZ, APPLIED PHYSICS LABORATORY; LARRY SODERBLOM, USGS; DAVID STEVENSON, CALTECH; AND PETER THOMAS, CORNELL UNIVERSITY


MIMAS
ENCELADUS
TETHYS
DIONE
RHEA
TITAN
1000 km
HYPERION
JAPETUS

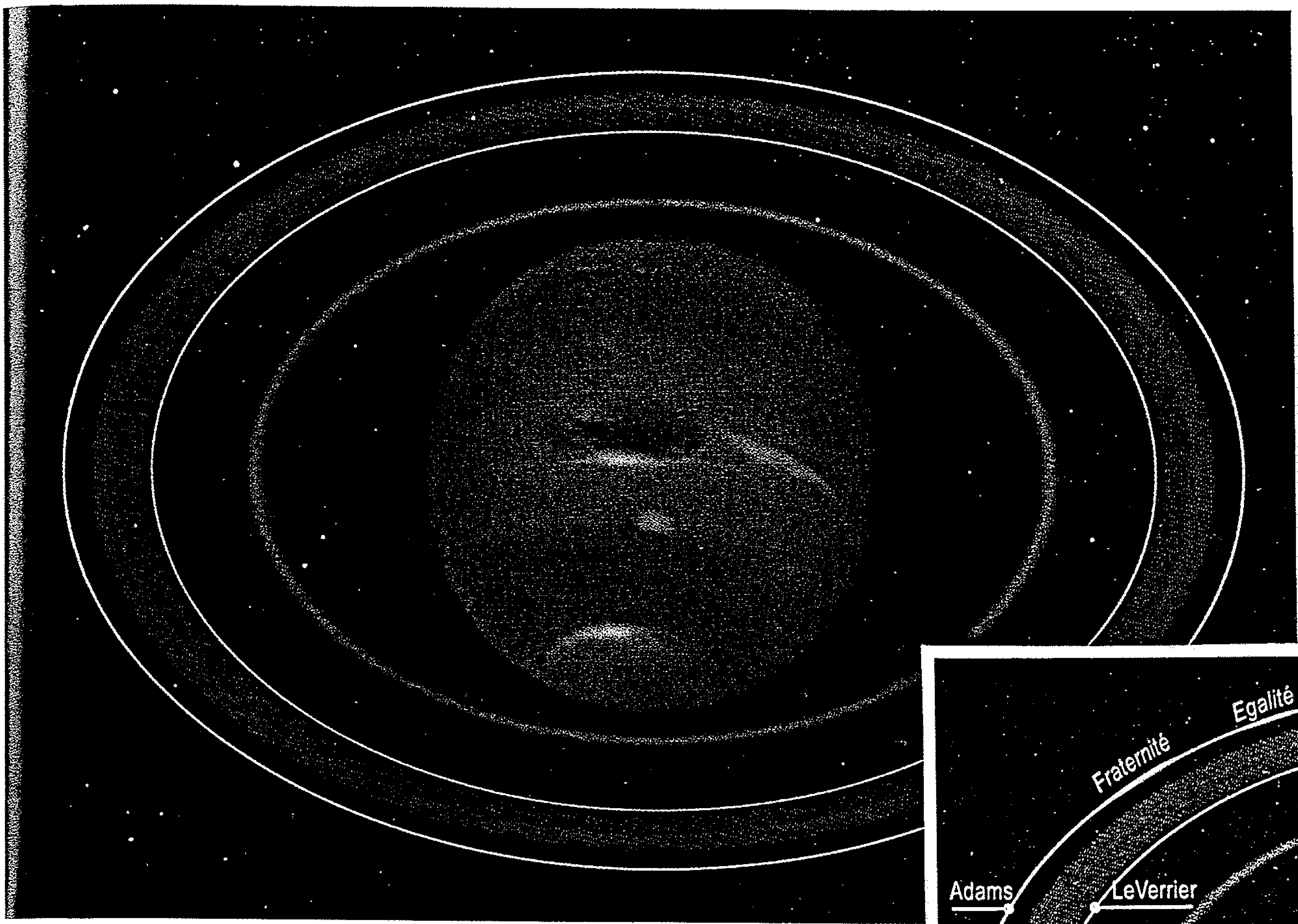
Vpravo: **Planeta Uran se jeví jako zelenomodrý kotouč bez nápadnějších podrobností;** *ty se skrývají pod vrstvou neprůhledného zákalu.* **Prstence Uranu jsou velmi úzké a ostře ohraničené** *(výjimkou je široký prstenec 1986 U2R), skládají se z jemného prachu a velkých částic (až 10 m v průměru). Devět prstenců bylo objeveno ze Země, zbývající dva (λ – lambda a 1986 U2R) objevil Voyager 2. Smluvené pojmenování prstenců je vyznačeno na obrázku vpravo uprostřed.*

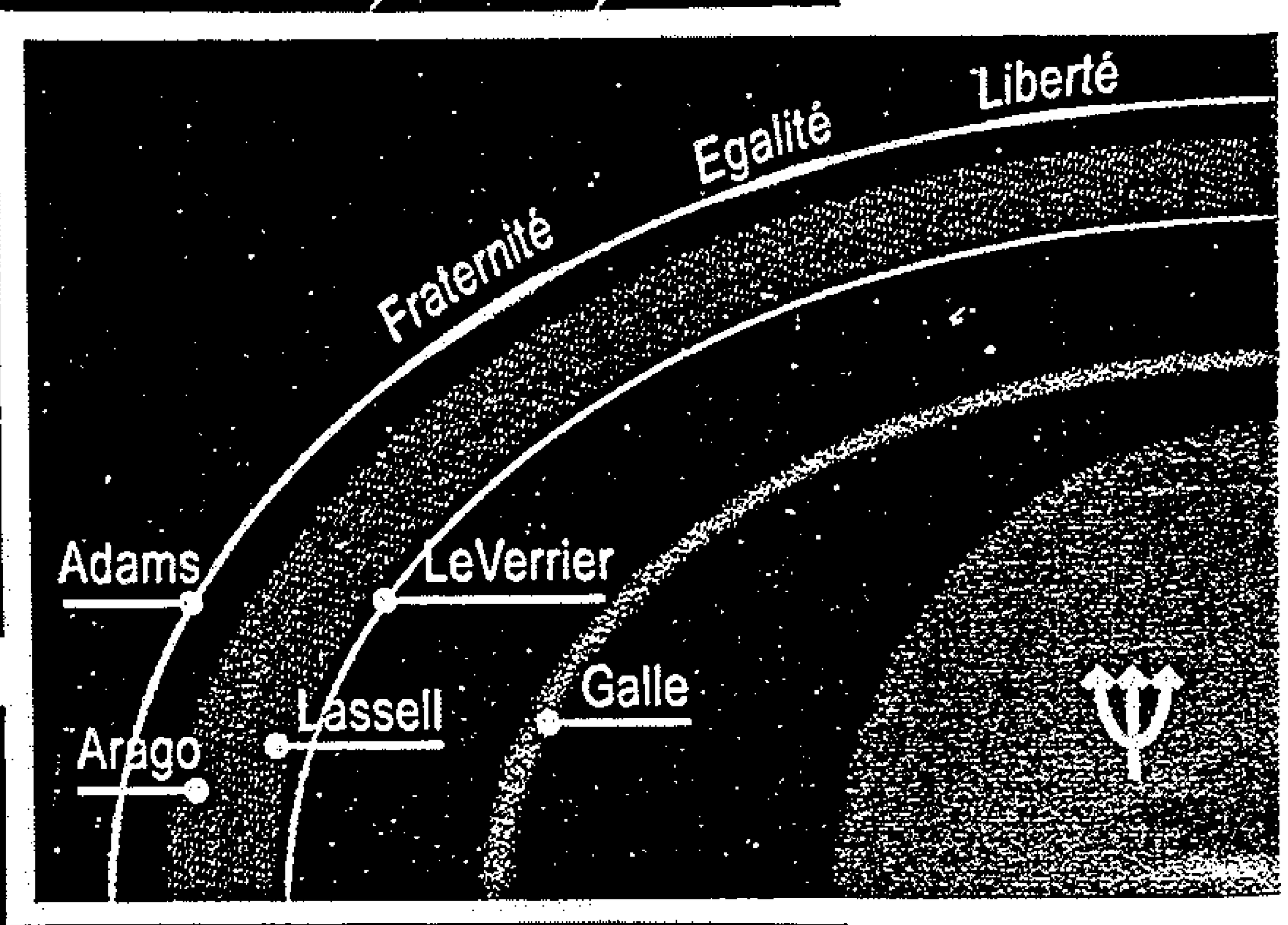




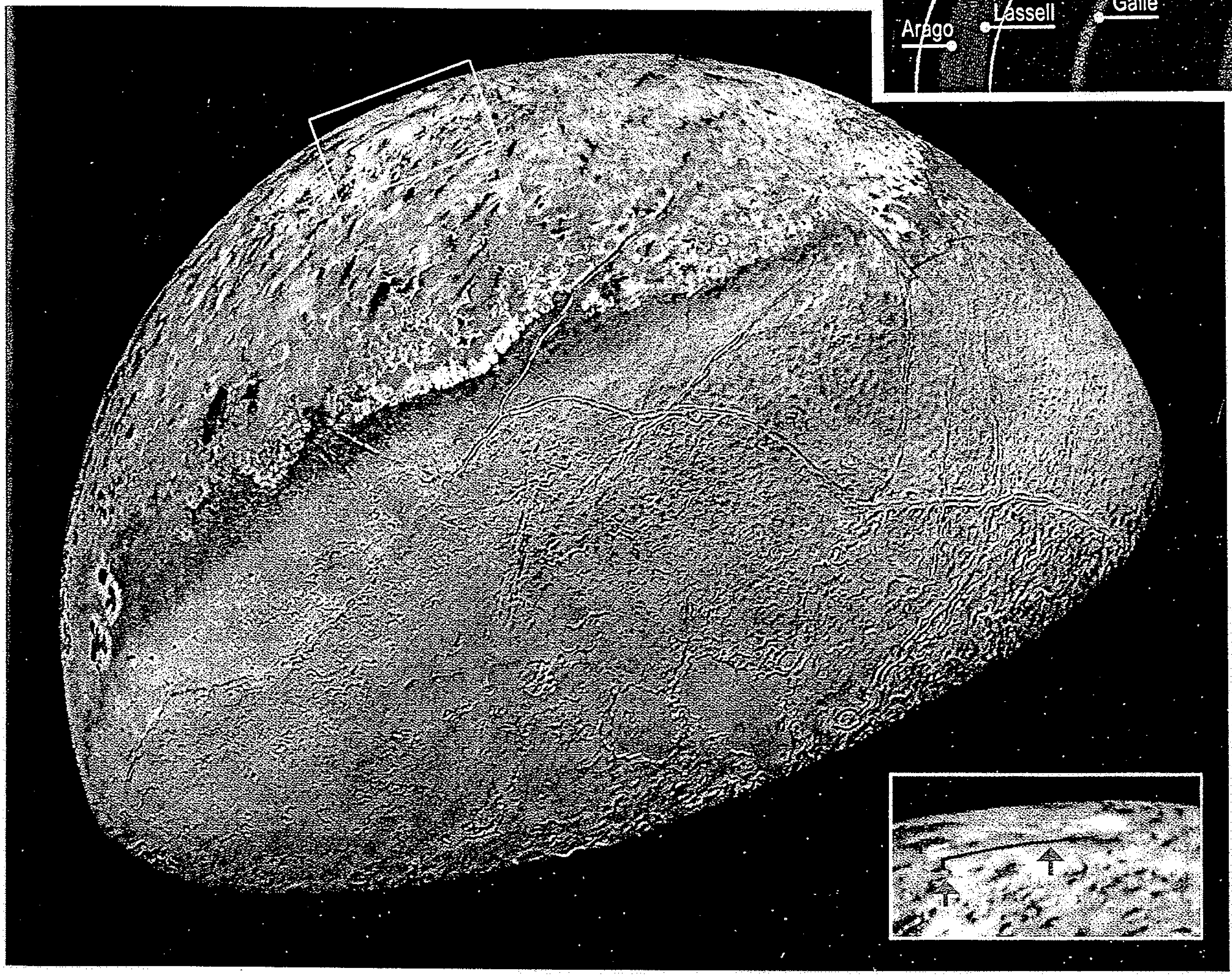


Vpravo: **Měsíc Miranda podle snímků ze sondy Voyager 2.** *Starý povrch, posetý dopadovými krátery, je místy vystřídán geologicky mladšími, ostře ohraničenými útvary; jejich vznik je nejasný, zdá se, že tu působily vnitřní síly. Podél zlomů a poruch v kůře snad mohl částečně změklý led vystupovat na povrch a vytvářet tam zbrázděné oblasti, jež pozorujeme. Dokladem o působení značných sil v kůře měsíčku je i* **mohutný kaňon se srázy vysokými 20 km** *(bílé, osvětlené svahy na pravém dolním okraji obrázku).*

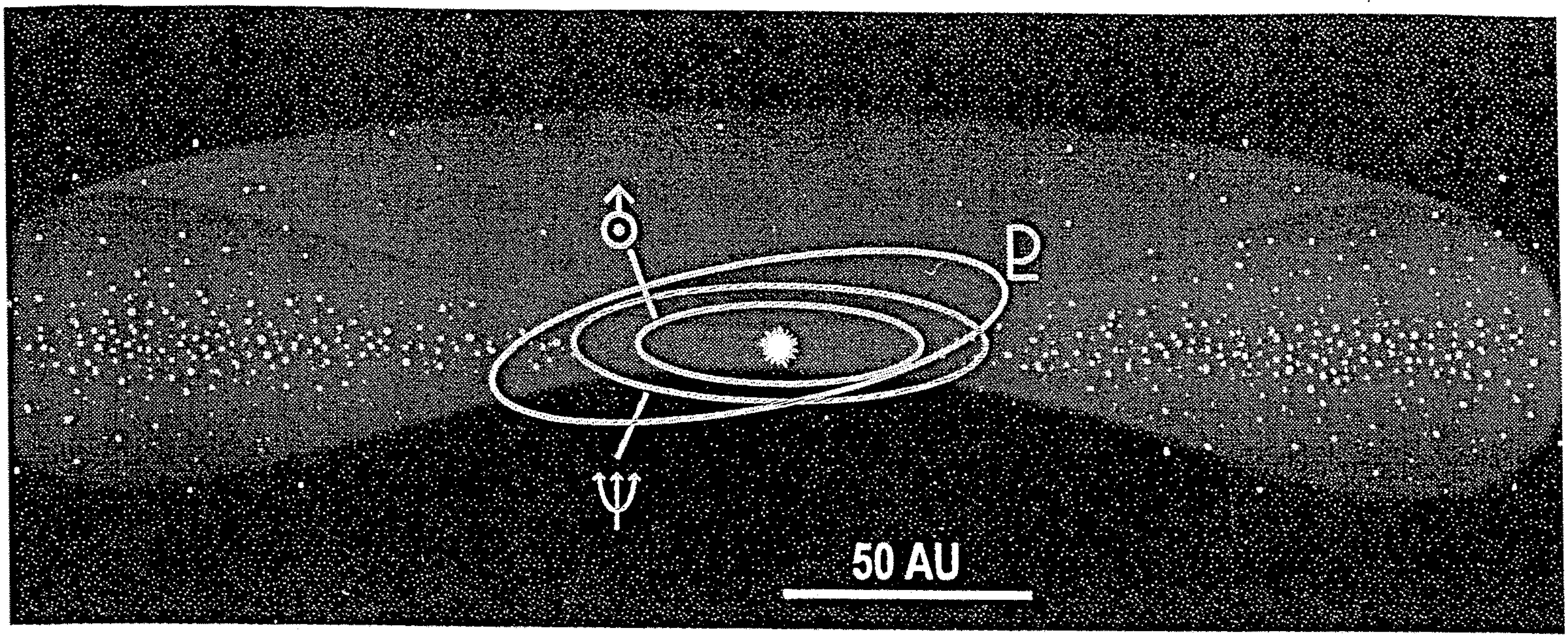




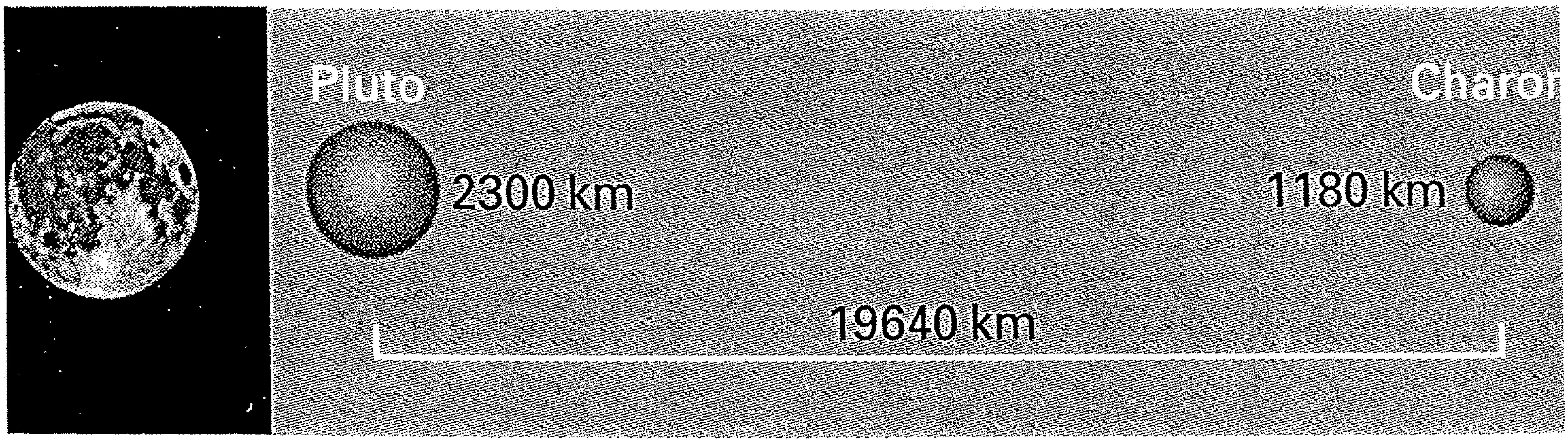
Liberté
Egalité
Fraternité
Adams
LeVerrier
Arago
Lassell
Galle
Ψ



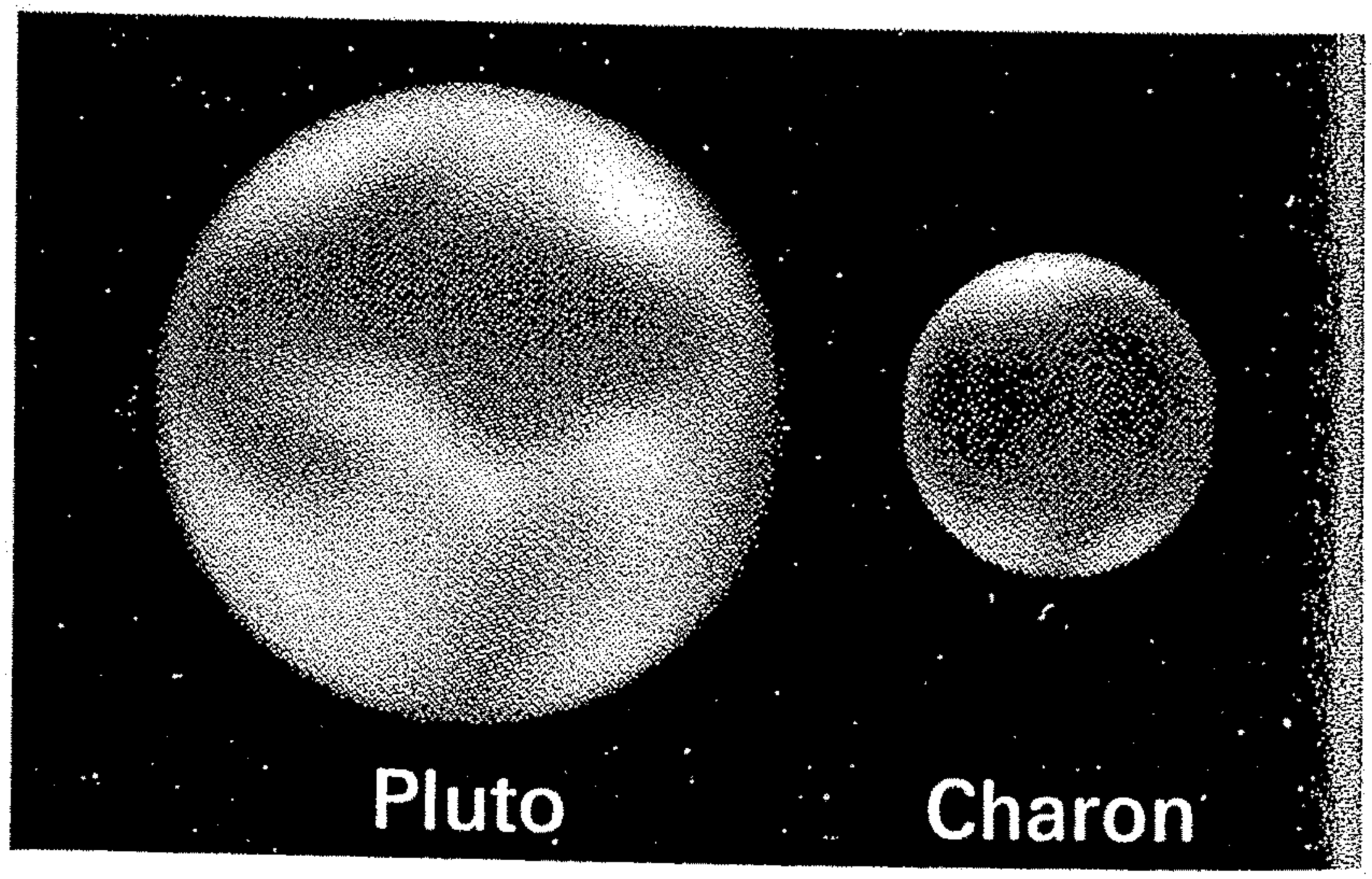
Dole:
***Vzhled a srovnání velikostí pěti největších měsíců Uranu. Zprava: Miranda** (průměr 472 km), **Ariel** (1158 km), **Umbriel** (1170 km), **Titania** (1580 km), **Oberon** (1523 km); pořadí odpovídá rostoucí vzdálenosti od planety, měsíce jsou vyobrazeny ve stejném měřítku.*



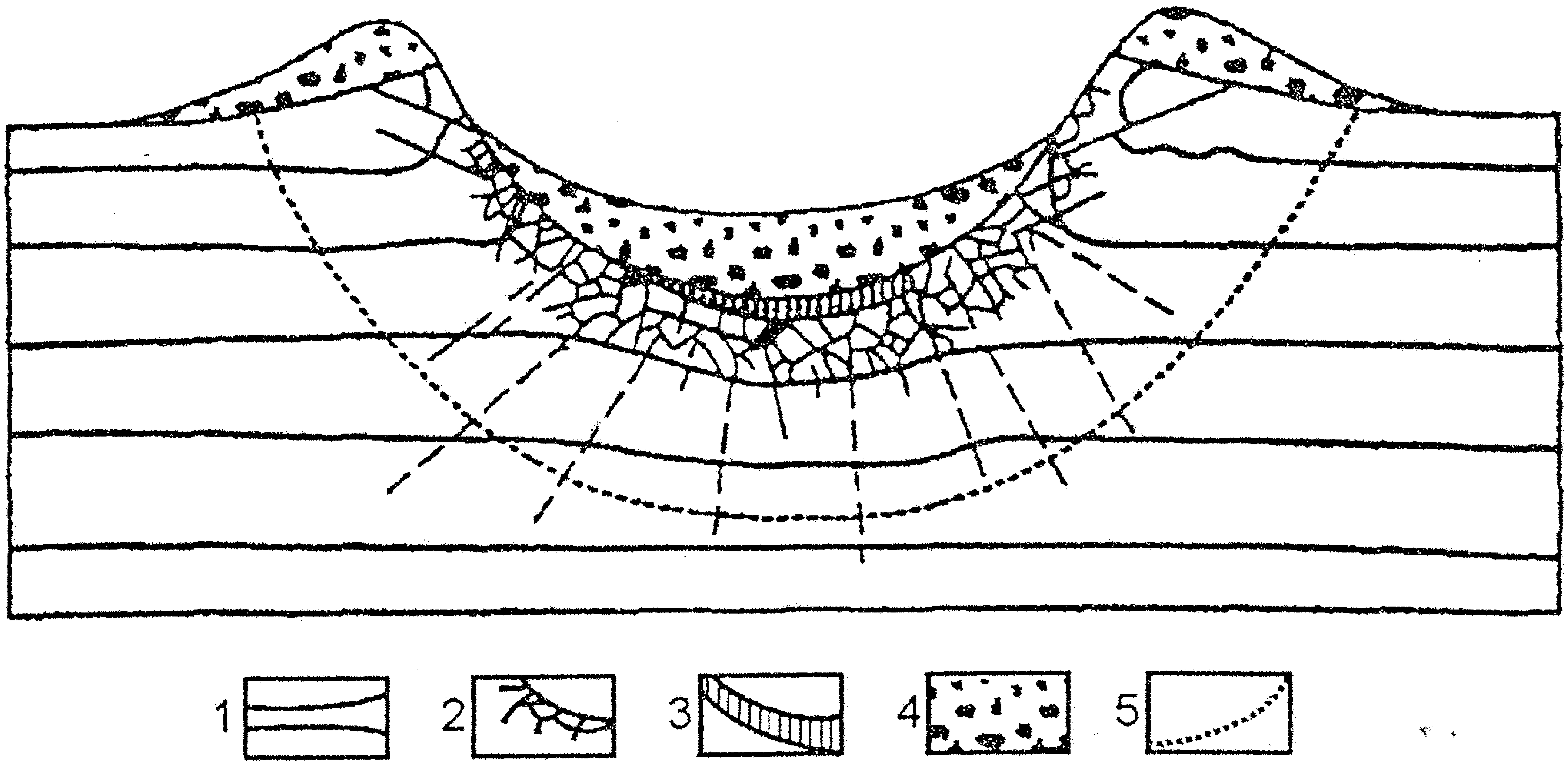
Vlevo: **Schéma Kuiperova pásu, zdroje krátkoperiodických komet,** jejichž oběžné dráhy se příliš nevzdalují od roviny ekliptiky. Vnější okraj disku pravděpodobně sahá mnohem dále, než naznačuje obrázek. Dráhy Uranu, Neptunu a Pluta jsou označené symboly planet.



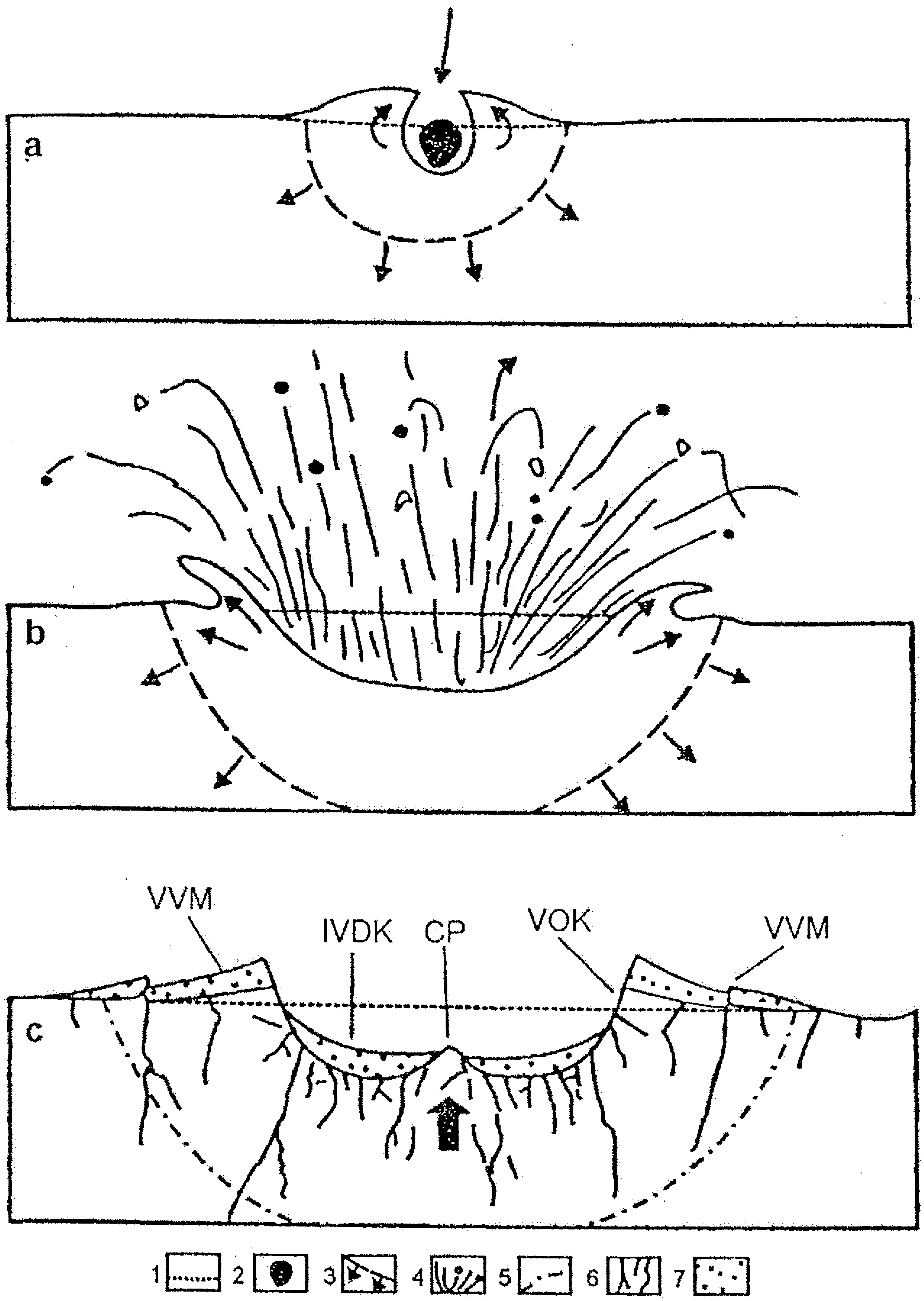
Dole: **Rozměry soustavy Pluto – Charon** ve srovnání s velikostí Měsíce.



Nahoře: **Objekty Pluto a Charon** zatím nebyly prozkoumány kosmickými sondami, známe na nich jen neurčité albedové útvary.



Obr. 2.2. Prierez jednoduchým impaktným kráterom. Vysvetlivky: 1 – horninový podklad s vrstvami deformovanými pri okrajoch krátera, 2 – brekcia z hornín podkladu rozbitých impaktom, 3 – impaktit – brekcia tmelená sklom (suevit), 4 – sedimenty impaktných vyvrhnutín, 5 – hranica plastickej deformácie (približne tiež rozsah šokovej premeny hornín). (upravené podľa Masaites et al 1979 ex Suk 1983)



Obr. 2.3. Vznik (komplexného) impaktného kráteru. a – Dopad a zaborenie sa meteoritu do povrchu planéty, šírenie tlakovej vlny do podložia, b – explóziou spôsobené preklopenie okrajov krátera, výtrysk a pád vyvrhnutého materiálu na dno krátera, jeho okraj (okružný val vyvrhnutín) i do vzdialenejšieho okolia), c – natavenie, šoková premena, rozpukanie a vznik hlbokých zlomov v podkladových horninách. Centrálny pahorok komplexných impaktných kráterov je následok izostatického zdvihu. Vysvetlivky: 1 – povrch pred impaktom, 2 – meteorit, 3 – tlaková fronta, 4 – expandujúce horúce plyny, prach a natavené vyvrhnuté úlomky z hornín a meteoritu, 5 – hranica šokovej premeny hornín, 6 – zlomy a hlboké pukliny, 7 – vyvrhnutiny okrajového valu a dna krátera, VVM – val vyvrhnutého materiálu, VOK – vyvýšený okraj kráteru, CP – centrálny pahorok, IVDK – impaktné vyvrhnutiny kráteru. (upravené podľa Gaulta et al 1968 a Masaitesa et al 1979)

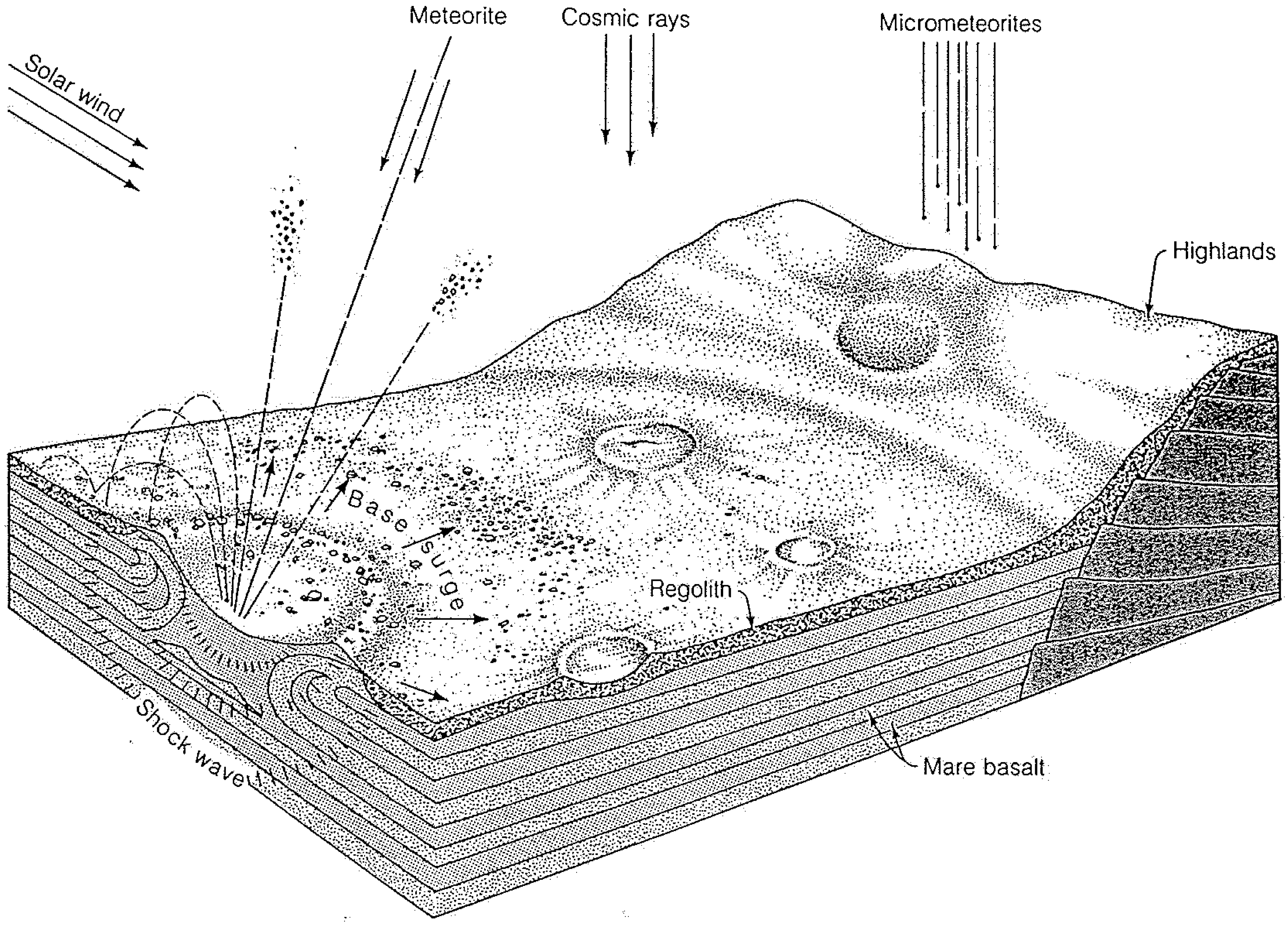


Figure 22-8

The original crust of the Moon, still present under the highlands, was broken up by large impacts. Afterward the basins were flooded by basaltic lava. Erosion of the surface, extremely slow compared to that on Earth, removes only about a millimeter in a million years. Bombardment by micrometeorites is believed to be the main cause. Larger meteorite impacts occur rarely, but they create craters and scatter ejecta over large distances. The regolith, up to a few tens of meters thick, is the accumulated, fragmental debris of billions of years of exposure to meteorite bombardment, cosmic rays, and the solar wind. [After "The Carbon Chemistry of the Moon" by G. Eglinton, J. R. Maxwell, and C. T. Pillinger.]

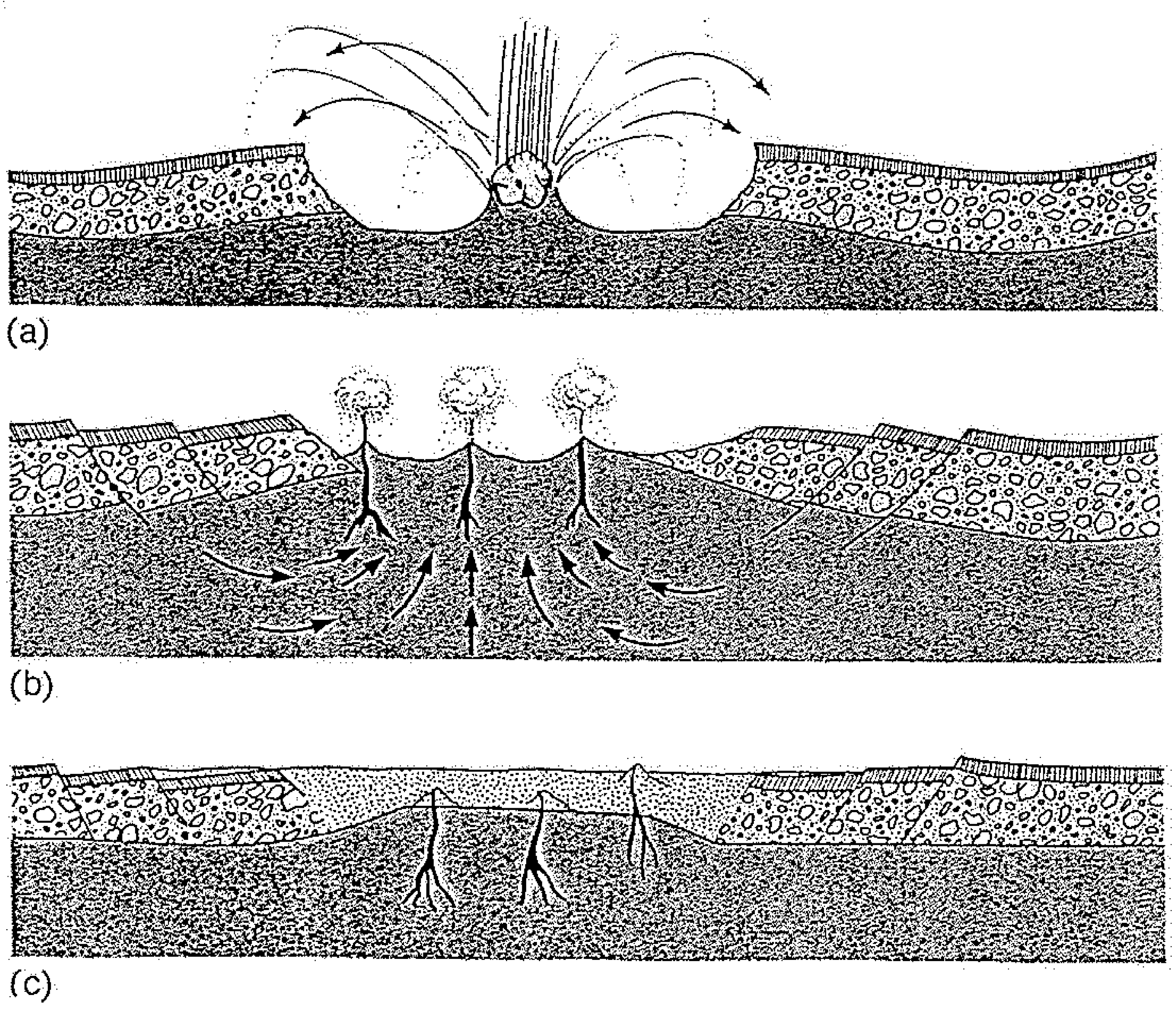
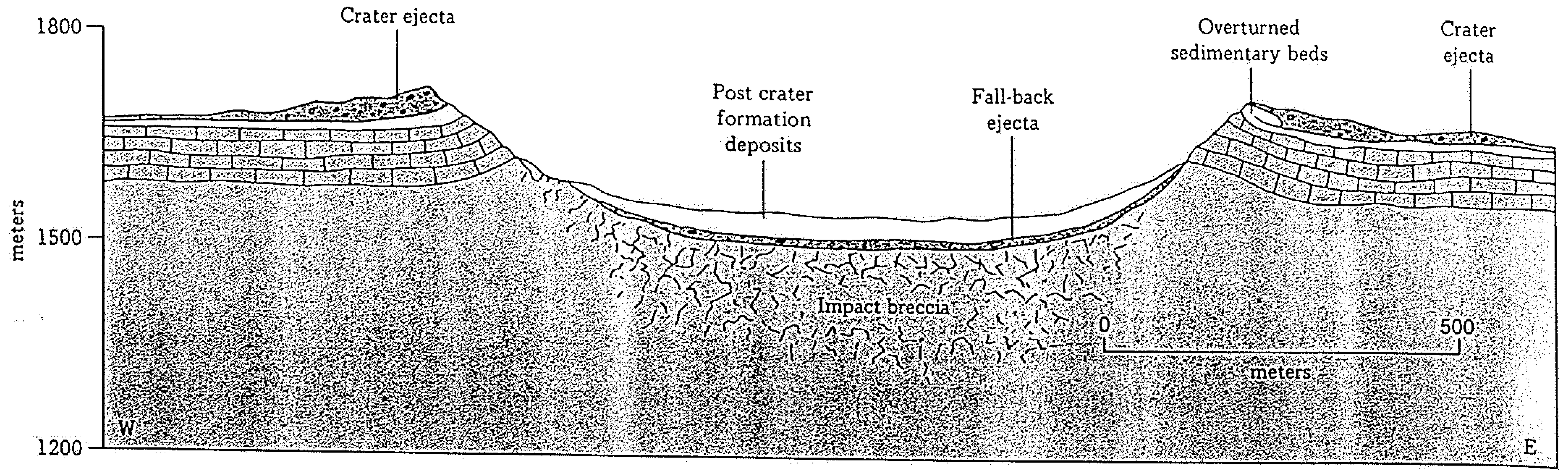


Figure 22-10

Model for the origin of the lunar maria. (a) The impact of a large meteorite excavates a basin, throwing material great distances. (b) The high temperatures generated by the impact cause volcanic activity. Alternatively, volcanism may be caused by fractures that reach partially molten rock beneath the lunar crust. (c) The basin fills with lava from the interior. [After NASA.]

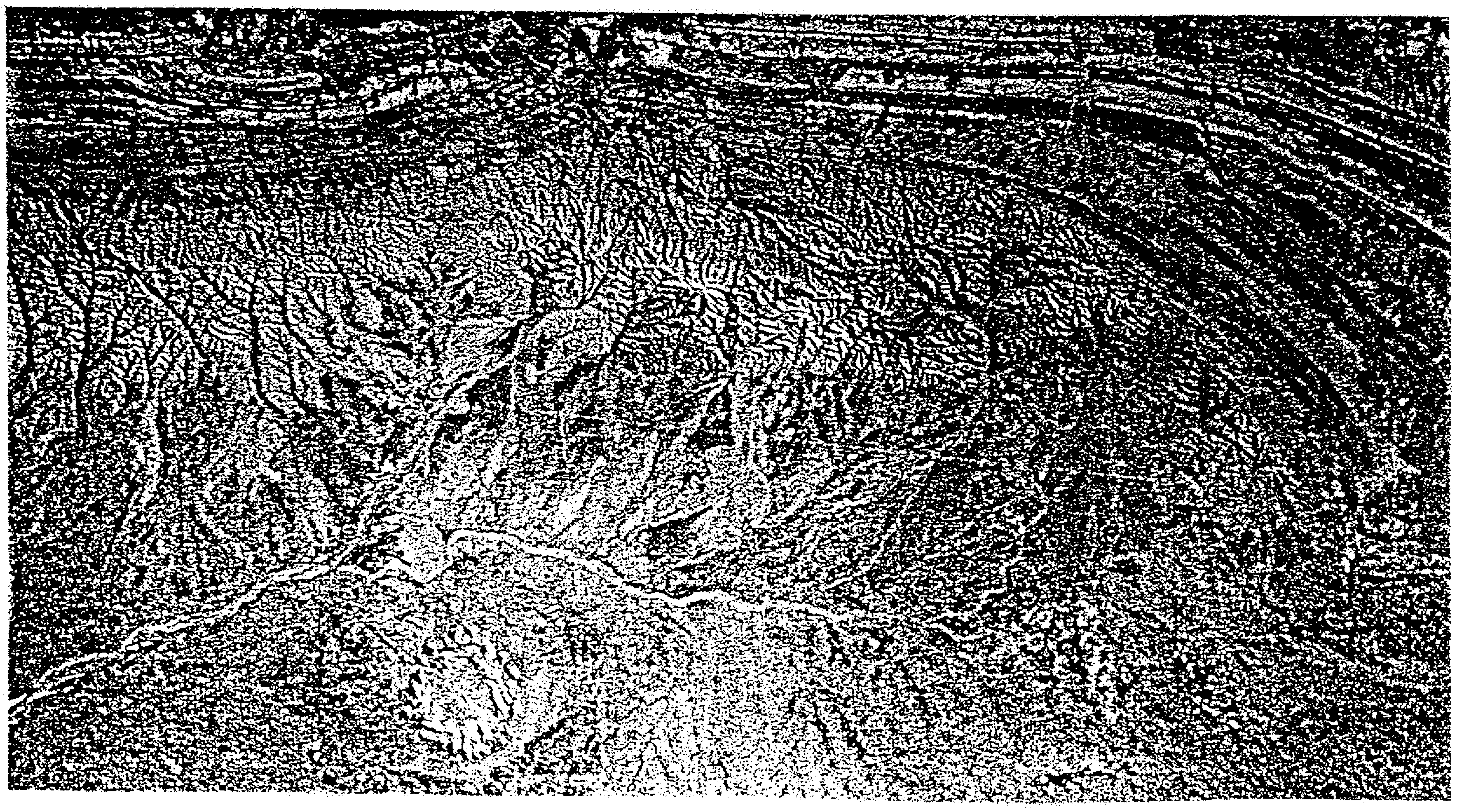


20.25 Geologic section through Meteor Crater. [After E. M. Shoemaker, "Penetration Mechanics of High-Velocity Meteorites, Illustrated by Meteor Crater, Arizona," *21st Int. Geol. Congress, Norden*, vol. 18, pp. 418–434, 1960.]

Figure 22-5

Meteor Crater near Flagstaff, Arizona, is about the same size as the lunar crater in Figure 22-4. It was caused by the impact of a large meteorite in prehistoric times. Thousands of fragments of the meteorite have been found nearby. [From U.S. Geological Survey.]

20.28 Gosses Bluff Crater, Macdonnell Ranges, central Australia, is the circular feature in the lower part of the picture. The light-colored rim is 3 km in diameter and represents the central uplift in the crater. Overall the crater measures about 20 km in diameter. Its outer portion is marked by the circular zone of discontinuous darker material outside of the inner ring. [NASA, STS-41D, August–September 1984, Picture #14-41-028.]



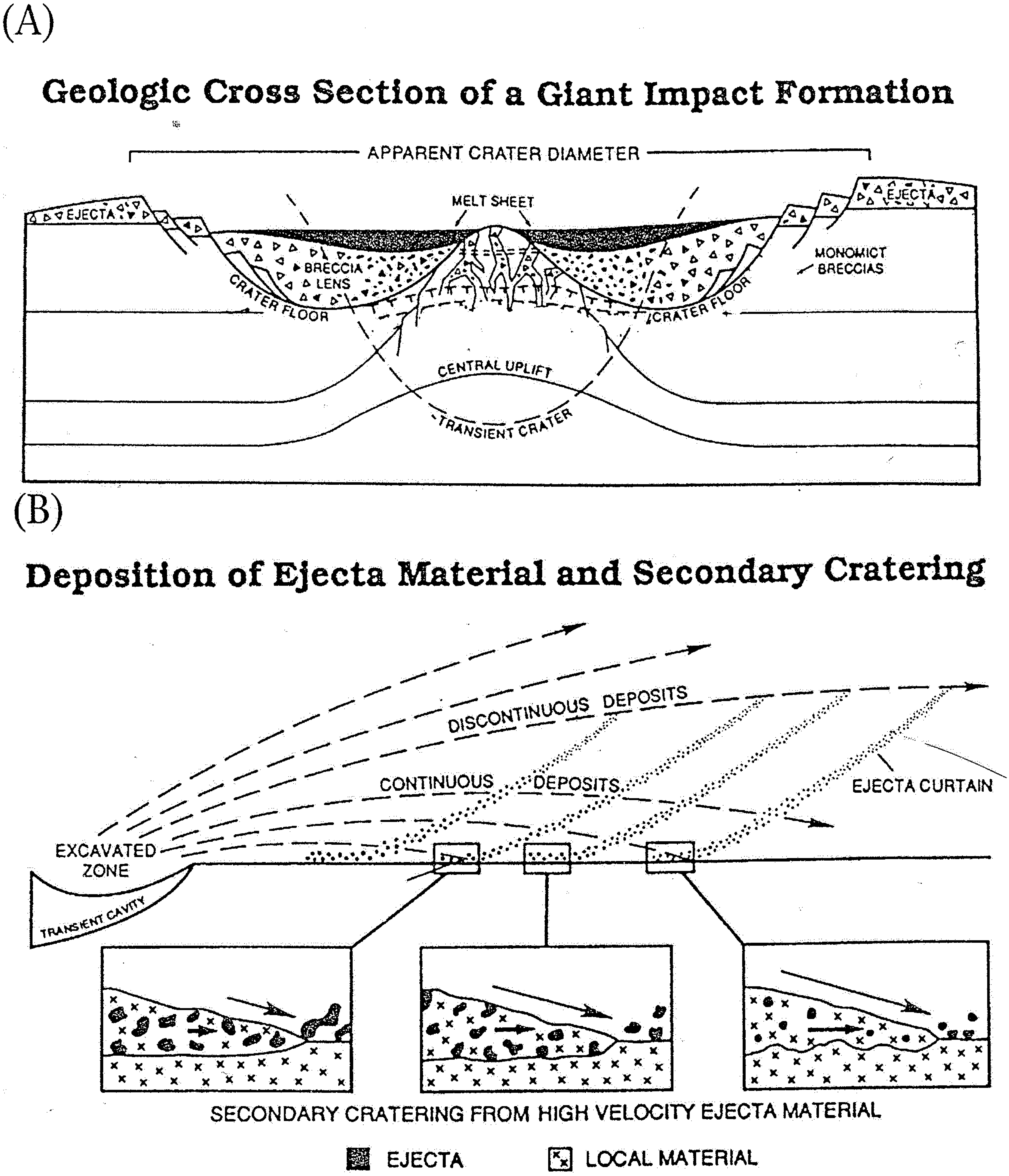


Figure 3.10. Diagrammatic cross-section of a terrestrial impact crater such as proposed for the Yucatan Peninsula based on NASA sources (an analogous structure, the lunar impact crater Humboldt, 200 kilometers in diameter, is approximately the same size as the proposed impact at Chicxulub). The structure of such a crater is illustrated in (A). In addition to shock features, fragmentation, and impact melting, the collision would expel an extensive spray of ejecta from the crater. Airborn debris from the spray, such as the glass droplets of melted rock found in Beloc, Haiti, eventually landed far from the point of impact, as shown in (B). See text for discussion. (*Source:* NASA pamphlet, 1993.)